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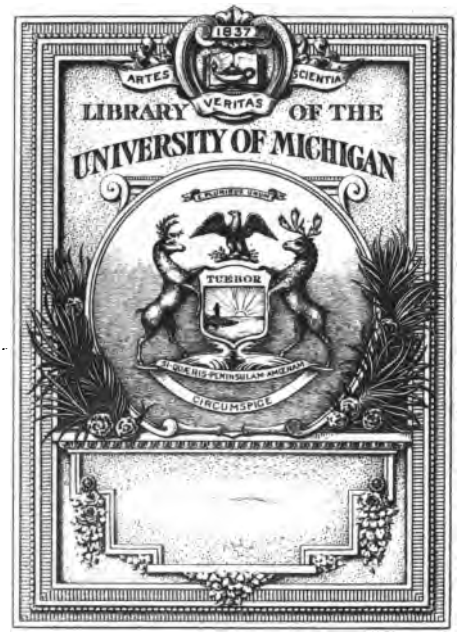
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REPORT OF PROCEEDINGS

OF THE

EIGHTH ANNUAL MEETING,

HELD

AT THE ROYAL DUBLIN SOCIETY'S ROOMS,

KILDARE STREET, DUBLIN.

JUNE, 1871.

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BRITISH
ASSOCIATION OF GAS MANAGERS.

REPORT OF PROCEEDINGS,
1871.

The Eighth Annual General Meeting of this Association was held in the Theatre of the Royal Dublin Society, Kildare Street, Dublin, from the 12th to the 15th of June, 1871.

TUESDAY, JUNE 13.

The first sitting was held this morning, when the chair was taken at eleven o'clock by EDWARD WHITE, Esq., of Birmingham, Vice-President.

The HONORARY SECRETARY (Mr. W. H. Bennett) read the minutes of the seventh annual meeting held last year in London.

On the motion for confirming the minutes,

Mr. OHREN (London) said there appeared to him to be a slight mistake in the minutes. Towards the close of the last annual meeting, Mr. Methven, of Bury St. Edmund's, proposed an alteration in rule 7 of the association, which, as amended during the discussion upon the proposition, was to the effect that the president for the past year should be *ex officio* a member of the committee. The alteration was unanimously adopted by the meeting, but, according to the minutes, it appeared that "the president ruled that notice must be given" before it could be made. As chairman on the occasion, and having made himself thoroughly acquainted with the rules of the association, he could not possibly have made such a mistake. No notice of the kind was required. All that was necessary was that the matter should be discussed in committee before being submitted to the general meeting. It was so discussed, and he was convinced the alteration was unanimously adopted by the members. He looked upon this as an important question, and therefore he now moved that the words "president for the past year" be added to rule 7, and that the minutes be amended accordingly.

Mr. HODGSON JONES (London) seconded the motion.

The HONORARY SECRETARY said he was under the impression at the time that the objection taken by Mr. Williams to the amendment of a rule without notice to the members generally was held by Mr. Ohren, as the president, to be irregular, and that the motion made by Mr. Methven never was put to the vote. In this view of the matter he was confirmed by the report of the proceedings of the association in the JOURNAL OF GAS LIGHTING.

Mr. OHREN said he had mentioned the subject to several friends who were present, and they all agreed in the view he had expressed, that the motion was ut and carried.

Mr. BROADHEAD (Great Grimsby) said at an earlier stage of the meeting he had asked whether notice to amend a rule was necessary, and Mr. Ohren replied that it was not. It would have been inconsistent had he afterwards ruled that Mr. Methven's motion could not be put.

It was then resolved, upon a show of hands, that the minutes be amended, by inserting that the resolution proposed by Mr. Methven at the meeting of 1870, on rule 7, was adopted, and that the rule itself be altered so as to read as follows:—"The president, president for the past year, vice-presidents, trustees, and honorary secretary shall be *ex officio* members of the committee."

The HONORARY SECRETARY read the following list of applications for membership which had been submitted to the committee :—

ORDINARY MEMBERS.

Andrews, H. W.	Dublin.
Ambler, W.	Saltaire.
Brown, A.	Woodford.
Bailey, W.	Camborne.
Box, W. W.	Crayford.
Baker, J. W.	Limerick.
Barton, A.	West Cowes.
Catlin, W. H.	Dublin.
Dear, J. G.	Baldock and Welwyn.
Daniel, W.	Dublin.
Dougall, A.	Kidderminster.
Edmond, J.	Newtown, Montgomeryshire.
Gibb, A.	Lurgan.
Greenfield, J.	Torquay.
Genever, E.	Dunedin, New Zealand.
Harris, F. M.	Falmouth.
Hollwey, J.	Kilkenny.
Hutchinson, C. H.	Barnsley.
Iddon, R.	Southport.
Jenkin, J.	Southampton.
King, R.	London.
Lane, Denny	Cork.
Martin, T. H.	Crewe.
Manning, H.	Hythe.
Meiklejohn, J.	Dungannon.
Price, R.	Llandudno.
Philpots, F.	Dursley.
Pierson, H. S.	London.
Randall, J.	Tottenham.
Still, A.	Cork.
Stelfox, J., jun.	Belfast.
Warsop, H.	Nottingham.
Whitaker, W. B.	Belper.
Wilson, J.	Abingdon.
Wilton, J.	Silvertown.
Wroe, J.	Rhyl.
Whitehead, W. S.	Bradford.

It was unanimously resolved—"That the gentlemen whose names have just been read be elected ordinary members of the association."

The HONORARY SECRETARY read the names of the following gentlemen who had applied to be admitted

EXTRAORDINARY MEMBERS :—

Bewlay, H.	Birmingham.
Laidlaw, D.	Glasgow.
O'Neill, J. W.	London.

These gentlemen were unanimously elected extraordinary members.

Mr. R. H. JONES (Dover) said he had given notice to the committee of his intention to propose the following rule :—"Should the president, after election, decline or be unable to perform his duties, then the chairman presiding at the annual meeting of the association shall be deemed the president for the year, and shall thereafter be described as the 'past-president.'"

The PRESIDENT said the committee had received the notice, but did not agree in the proposed alteration.

Mr. JONES said the association elected a president for the past year who declined to act as president on this occasion, and unless some such change as he proposed were resolved upon, they would be without a head for the remainder of the year.

The PRESIDENT said as soon as he vacated the chair the gentleman who

would occupy his place at the next meeting would be president for the intervening year.

Mr. JONES said practically during the past year the association had been without a president, and if any important matter had required the members to meet, there would have been no one to convene them.

The PRESIDENT said the circumstance was very unfortunate; but it should be remembered that, in view of such a contingency, three vice-presidents were annually elected.

The HONORARY SECRETARY said Mr. Livesey was still the president, although he had declined to pay a visit to Dublin on the present occasion.

Mr. G. ANDERSON (London) said the person who performed the duties of the office should be honoured with the title of president. Mr. Ohren having been called to the chair at the last annual meeting, in consequence of the illness of the past president (Mr. Esson), should be described as the president of the past year. The vice-presidents were quite competent to act as presidents if necessary; but if they did so act, they should receive the title of past-presidents.

Mr. BROADHEAD said he supposed Mr. White would hereafter be described as one of the past-presidents.

Mr. ANDERSON said he understood Mr. Ohren had not been summoned to any of the committee meetings of the past year, and it was to prevent such a thing occurring again that the alteration was proposed.

Mr. NEWALL hoped the motion would not be pressed. The existing rules provided that in the absence of the president the vice-president should take the chair. It must be understood that the taking of the chair at the annual meeting was the last presidential act, and not the first. The president was elected on the last day of the sittings, and he continued to act until his successor was appointed at the close of the next year's meeting.

Mr. WARNER said he thought the existing rule on the subject was sufficient.

Mr. G. ANDERSON thought it was not so clear as it should be, as there was evidently some misunderstanding in the committee respecting it. He himself, according to the rule, should, as a vice-president, have been invited to the meetings of the committee, but never had been.

The HONORARY SECRETARY said the reason was because Mr. Anderson, at the last annual meeting, intimated that he preferred retiring from the vice-presidentship in favour of the gentleman next highest on the ballot; and subsequently, on him (the secretary) writing to Mr. Anderson to ask whether he really refused to accept office, he replied—"Please to omit my name from the list of vice-presidents."

Mr. JONES said that would not apply to Mr. Ohren, who, though past-president, was not invited.

The HONORARY SECRETARY said that was because he was under the impression the rule had not been altered.

Mr. D. LANE (Cork) thought the whole difficulty would be removed if they resolved that not only the past elected president, but the past acting president of any year, should be *ex officio* a member of the committee for the ensuing year. He would move a resolution to that effect.

The PRESIDENT said notice of such a motion must be previously given to the committee. It could be brought forward the following day.

Mr. R. H. JONES's motion, not having been seconded, fell to the ground.

The PRESIDENT then delivered the following

INAUGURAL ADDRESS.

For many reasons I must express my regret that circumstances have placed me in the position I occupy here to-day. I am exceedingly sorry that this chair is not filled by our worthy president, Mr. T. Livesey, whose long experience and great knowledge of gas affairs would have added to the interest, and promoted the success of this meeting. Mr. Livesey, however, has found it impossible to attend, and I have been called upon, unexpectedly, to fill his place. I must, therefore, ask your indulgence while I endeavour to fulfil the duty which devolves upon presidents at gatherings such as ours, and deliver what is called the Inaugural Address.

I cannot but call to mind that I have been preceded in the chair by some of the most eminent men connected with gas matters, to whose addresses we have listened with pleasure, and at the same time have received much instruction. It will not, I know, be expected of me that I should attempt to take in the broad view of gas affairs which distinguished the addresses of Mr. Hawksley and

Mr. Barlow. But as I yield to no one in appreciation of the value of such an association as ours, I shall do my best under the circumstances in which I am unexpectedly placed, and ask your indulgence for any shortcomings which may be too evident.

This, you are aware, is but the eighth annual gathering of our association, and I may be excused if I review with pride the rapid progress it has made in the few years which have passed since that first modest meeting, as I may call it, at Manchester, when some 40 gentlemen enrolled themselves as members. Year by year since then the association has steadily increased in numbers, and, I may add, in influence also; and last year's meeting found us with 323 members—a number which will be considerably added to this year. Nor need we pride ourselves upon an increase in numbers alone. Any one who looks back through the volumes of our Transactions will see how worthily the objects for which the association was called into existence have been carried out. He will have no doubt on his mind that the association has devoted itself "to the encouragement and advancement of all matters connected with gas engineering, manufacture, and finance," and has been eminently useful in facilitating the exchange of information and ideas among its members. I believe it impossible to over estimate the usefulness of an association such as ours, which provides for the free interchange of thought, and the open communication of information among men having one common interest; and I hope that every year will bring accessions to our ranks, and that ere long a gas manager who is not a member of our association will be a rarity indeed.

But while I congratulate you on the addition to our numbers, I cannot forget that men are mortal, and one painful duty of a president, on these occasions, is to pay a tribute to the memory of members who have passed away in the interval since the last meeting. Last year, as now, the chair, although ably filled, was not filled by what I may call the legitimate occupant. Our then president was ill—lying on his death-bed, in fact, for he died very shortly after. Mr. Esson was an early member of this association, and was elected on the committee at the first annual meeting. From that day until his death he did, I believe, his utmost to promote the success of the association, not only by his earnest labours on the committee, but by contributing papers at our annual gatherings. In 1867 he gave us a lucid account of the manufacture of sulphate of ammonia as carried on at his works in a way profitable to his company, while avoiding the nuisance, &c., commonly experienced in the production of this salt from gas liquor. In the following year he gave us a description of an improved arrangement of a purifying-house and apparatus, which will be found, with very useful illustrations, in our report for 1868. The next year he described a substitute for the hydraulic main, and also a registering gas quality test. These were unhappily his last communications to our reports. In the following year he died—an amiable and estimable man, who will be long and affectionately remembered by all who had the happiness of knowing him.

Another deceased member who cannot be passed over without mention is Mr. James Sharp, of Southampton. I find but one record of his appearance at our meetings—namely, in 1868—when he opened a very useful discussion on the deposit of naphthaline in pipes; and you will excuse me for remarking here that no one renders a greater service at these meetings than he who originates a discussion on some practical point of general interest. In early life he was apprenticed to a watchmaker, but in later years he devoted himself to the business of a general mechanist, and afterwards, on the formation of the Northampton Gas Company, entered their employment as assistant manager. He subsequently removed to Winchester, and afterwards to Southampton, as the manager of the gas-works in that town. There he lived for many years, highly successful in the management of the gas undertaking, and enjoying the esteem of all his fellow-townsmen. He died on the 4th of September last year, at the ripe age of eighty.

Two matters were, at our last meeting, referred to the consideration of your committee, one of which concerns us all as members, and the other has a particular interest to the men working under us. I allude to the Benevolent-Fund and Sunday Labour Questions.

On both the questions you are aware that your committee have taken pains to ascertain the opinion of each member individually, and reports will be presented to you setting out the opinions expressed. As to the benevolent-fund,

I am sorry to say that the committee have not found such uniformity of opinion to exist among the members, either as to the object of the fund or as to how it could be maintained, as to justify them in recommending any scheme of the kind for your adoption.

I fear that in the opinion of many it was the intention to found a sick or benefit club, but as almost every town has such an institution, it would, in my opinion, be quite unnecessary, and I think I may say such was not the intention of the mover of the resolution. But what I think we might with propriety and advantage do would be to commence a fund, each member subscribing according to his means and inclination, from which assistance might be given to brother members under unusual circumstances of trial or misfortune.

As regards the Sunday labour question, you will probably have some suggestions made to you.

I think that in moderate sized works, or even large ones, in the summer season, some arrangement might be made to diminish Sunday labour—that is, provided the men could be depended on to adhere to their part of the arrangements. I am very sorry to say, however, that my experience of the class of men employed as stokers forbids the hope that they would make the slightest sacrifice even to ensure to each other certain days of Sabbath rest. Could I be assured of the steady co-operation of the men to aid the movement, I for one should be glad to assist in carrying it out.

The papers already announced for this meeting, so far, at all events, as I may judge of them from their titles, and from what I know of the abilities of the several authors, are fully up to the standard of those read at previous meetings. The subjects are eminently practical, and therefore of universal interest. Mr. Paterson's paper will, I presume, be a continuation of the valuable communication he made to the association three years ago, in which, it will be remembered, he gave us not only an excellent description of the various kinds of cannel, but also a valuable account of the quantity and quality of gas obtained from each sort.

The subject that Mr. Warner proposes to introduce to the meeting is also of great practical interest. As to the best form of condenser gas engineers are not as one in the matter, and if Mr. Warner will furnish us with results which will assist us in deciding which form is best to employ, I am sure we shall all be thankful to him.

The new equilibrium gas-governor, which has been invented and will be described by Mr. Charles Hunt, will, I hope, be proved to be a valuable invention. Of the economy of employing exhausters no engineer, I think, can have a doubt; and Mr. Anderson, than whom no one is better able to treat of this matter, will, I expect, furnish us with some valuable practical information. His remarks will, I understand, be illustrated by exhausters in actual operation at the Alliance Gas-Works, which you will be invited to view.

Much, I believe, would be gained if the small gas-works scattered about in the country in agricultural districts, could at once make up their ammoniacal liquor into a marketable commodity, which is always in demand in their districts. The works in those localities are always small, and their residual products are nearly always wasted. Mr. Eldridge will, therefore, render not only the gas companies, but the community at large the greatest service, when he shows us how sulphate of ammonia can be made with ease and profit at small gas-works.

The subject of the communication which Mr. Somerville will make to us is also one of great practical interest. There are few managers, I imagine, who have not been annoyed by choked ascension-pipes, and Mr. Somerville will deserve the thanks of most gas engineers when he has taught us how these obstructions may be readily and effectually prevented. Nothing is of greater importance to the successful management of gas undertakings than an exact knowledge of the cost of the production and distribution of our gas. Every gas manager has, no doubt, his own way of arriving at these details, all I dare say accurate enough. Still much trouble will probably be saved in many cases by the use of printed forms, such as will be laid before you by Mr. Warner and Mr. Niven in the descriptions of their carbonizing accounts.

There are two papers set down for reading, which are of great interest to others besides gas managers. I allude to those relating to the spontaneous combustion of coal. On this matter we may perhaps learn something from the

experience gained in this city. I will not anticipate anything the authors of these communications may have to say, further than to express a hope that we may receive from them such explanations of the causes of these accidents as may teach those who are liable to them how to prevent them in the future, not only in the stores of gas-works, but in other places, such as the holds of steamships, where similar occurrences have more than once led to an awful loss of life.

A paper is promised by Mr. F. W. Hartley, "On Gas Measurement," and I need not dwell on the importance of this subject to all gas manufacturers. I know it is said our means of measuring gas, whether as manufactured or sold, are not satisfactory. For my own part, although aware the instruments in use are not perfection, I believe, where proper care is taken in selecting the meters made by the best manufacturers, and avoiding such as are commonly called cheap, together with due inspection, comparatively few complaints will be received of imperfect or unfair registration. In this view I am fully borne out by my experience in connexion with the company I represent, for there have been but very few complaints, and whenever a dispute has arisen between a consumer and the company, necessitating a reference to the official tester, the meter has been found by him to be invariably correct. Still in this, as in all matters of commerce, it is very desirable that the most perfect instrument should be adopted, and from the great experience of Mr. Hartley, and his acknowledged mechanical skill, I am induced to hope that we shall gain some valuable information from him.

Lastly, I come to the title of two papers devoted to the utilization of tar. It is too early, perhaps, even to dream of the day when coal will be converted into gas with little or no production of tar, but it occurs to me that this is within the region of possibility, and will be eventually accomplished. In the meantime I cannot help thinking that the best application of tar as we find it is to convert it if possible into gas, and for that reason I rejoice that this subject is to be introduced for discussion by Mr. Arnott. Some experience on this matter, I believe I am right in stating, has been gained in this city; and we may hope to hear from Mr. Somerville of his results with one particular process, in which tar is incorporated with coal before it is introduced to the retort. Further than this I shall not anticipate anything Mr. Arnott may have to say on the subject.

As regards tar pavement, respecting which Mr. Anderson is to give us some additional experience, I may remark that objection has been taken to the plan as described to us by Mr. Methven last year, as involving great waste of valuable material in the boiling down of the tar as a necessary preliminary to its being mixed with the shingle or ashes, and which might be saved by previous distillation of the tar. This, doubtless, would apply to large works where the facilities for disposing of the tar to the distiller, and where a fair price is obtained for it, but in very many of the smaller works, where it is impossible to get rid of the tar at any reasonable price, I think Mr. Methven's simple and effective way of converting it into tar pavement well deserving the consideration of managers of small works. Without anticipating further what may be said on the subject, I will just say there is one way I consider would be very appropriate and, I think, successful—that is, to imitate as nearly as possible the material found in the Val de Travers, and which has been laid down in the City of London with so much success. This, as you are aware, is a limestone rock, which is permeated with from 15 to 20 per cent. of bituminous matter. It cannot, I hope, be beyond the reach of our mechanical skill to incorporate the pitch resulting from the distillation of tar with earthy materials to form a compound which may rival the natural compound in the ease with which it may be laid, and the stability with which it will endure. Failing the conversion of tar into gas, which I hope to see, I feel inclined strongly to protest against throwing away irrecoverably such valuable ingredients in the tar as the benzole, from which we derive such beautiful colours, and the carbolic acid, which has proved such a valuable disinfectant.

The legislation of the past year as it affects gas companies has been distinguished by one remarkable measure. I allude to the Gas and Water Works Facilities Act. The object of this Act is to enable gas and water companies to obtain at a cheap rate a Provisional Order from the Board of Trade, which by subsequent confirmation in a public Act confers upon them all the statutory

powers to be obtained by a private Act, which can only be acquired at a much greater cost. The measure is undoubtedly a good one, and many companies have this year availed themselves of its provisions. It has been supplemented by a bill for the amendment of the Gas-Works Clauses Act, 1847, which has excited the opposition of all the gas companies in the kingdom, and which is still under discussion. In its original form some of the provisions of this bill were as unjust as they were impolitic, but the provisions have been largely altered in an amended bill which may possibly pass into a law. To us, as managers, the bill may be said to be comparatively unimportant, but still we, who have the best possible practical acquaintance with the working of gas undertakings, may be allowed to point out how everything that tends to increase the expenses of a gas company must necessarily increase the cost of gas to a consumer, and so defeat the chief object of the bill. If we are compelled to resort to more expensive systems of purification, if all companies, irrespective of the size of their undertakings, are compelled to make maps of their districts, and to keep accounts in such unusual and peculiar forms, it must add to the expenses of our companies, and the additional cost must by a natural law fall on the consumer. Beyond this (the iniquitous confiscation clauses in bill No. 1 having been withdrawn) I see nothing to object to in the bill now before Parliament.

I may here make a few remarks on special gas legislation, as evidenced in the private Acts passed last year and those which are before Parliament this year. We see in these what I believe to be a thoughtless and unreasonable disposition to raise the illuminating power of the gas, while reducing the maximum price at which it must be sold. I say thoughtless, because our northern neighbours who insist upon 25 or 30 candle gas can hardly have taken into consideration the inevitable consequences of their acts. Whatever may be thought about the duration of our deposits of coal in general, there can be no doubt that our beds of cannel are very limited in extent, and that they are being rapidly exhausted. Guided by the prices alone, I find that an average rise of about 25 per cent. in the price of cannel coals has taken place in 20 years. This exceeds Mr. Jevon's estimate that the price of coal is doubled in a century. I cannot think that this steady and continuous rise of price in our raw material is sufficiently considered, either by the parties who propose or the Legislature which restricts us to a limit of price in perpetuity. In common gas coals a rise of price in accordance with Mr. Jevon's estimate has taken place, and we may be certain that in the course of no distant time, without some great discovery of which we have at present no suspicion, the manufacture of gas of high illuminating power from British coal will be impossible. Under there circumstances, I would point out the advisability of restricting ourselves to reasonable limits. In my opinion 14-candle gas, properly burned, is good enough for all purposes and for any place. Although, in my own case, I am compelled to supply gas of a superior illuminating power, I consider 14 candles to be ample; while in Paris—certainly, in its happy days, the best lighted city in the world—the gas was even of a lower quality. There would be one advantage in having gas of the same quality all over the kingdom, to which I shall make further allusion presently—namely, that the same burners would be applicable everywhere. But what I wish to insist on now is the necessity for economizing the consumption of cannel coals. This point was briefly referred to by one of our past presidents, whose opinion is particularly worthy of respect—I mean Mr. Hawksley—and was mentioned by Mr. Barlow, the other day, in his evidence on the Aberdeen Gas Bills. In spite of warnings like these, however, our municipal bodies continue to demand, and the Legislature continues to impose on us the obligation to supply gas of high illuminating power, when it seems more than probable that, in the course of a very few years, we shall find ourselves without the material to furnish it. A consideration of this kind gives great importance to a subject which I have said will be brought before you—the manufacture of gas from coal tar.

You will, doubtless, have observed the tendency in these days towards the absorption of gas undertakings by municipal authorities. To us, simply as gas managers, the matter is of no great importance; but since no one knows better than we do how often the undertakings in which people invest their savings remain unproductive for many years, I think we are bound, in the interest of our employers, to protest strongly against such a law as would allow a local board to buy up a gas undertaking at a disadvantage as soon as it was suffi-

ciently profitable to invite cupidity. The danger of the enactment of such a law has, for the moment, passed away, but it may any year recur; and we may place our protest on record for use when occasion requires.

Closely connected with legislation you will see is the vexed question of standard burners. Of these, as you know, we have a variety. I have before suggested that it would be highly desirable to have gas of as nearly as possible one uniform quality supplied all over the kingdom. Then we might hear no more of a Birmingham burner, a Dublin burner, or a London burner. But, in any case, I think we may admit, without hesitation, that a test-burner should be one capable of receiving general application by consumers; if not, I believe we set up a false and improper standard, of which the general public have a right to complain. We have an undoubted right to the use of the most perfect instruments; but, at the same time, they should be instruments which can be employed by our customers. Having said this, I may say a few words on the burners the public can and do employ.

There is an old proverb which says that heaven sends meat, but that cooks come from quite an opposite quarter. It is not for us to say where gas-makers come from, and I will make no insinuation as to the origin of some burner-makers; but this I may say, that however good the gas we make, we find its value very commonly depreciated to the extent of 50 per cent. by the burners employed in consuming it. Now this is a very important matter, and deserves the serious attention of all gas managers. Unfortunately, the greatest ignorance of the matter prevails among the public; and it would seem that gas-fitters are no better informed. To them a burner is a burner; and as they obtain it from the maker so they fit it up, without any thought or any examination. The experiments of our fellow-member, Mr. Kirkham, with the most commonly employed form of burner—the fishtail—show some remarkable differences with burners, professedly similar, bought indiscriminately. I shall take but one illustration, No. 4, iron burners, premising that the gas employed was the same in all the experiments:—

Experiment.	Fishtail Burner.	Illuminating Power in Standard Candles.
1	No. 4	11·11
2	„	9·36
3	„	6·43

I may quote also from the London gas referees report for 1869 the assertion that three fishtail burners, bought at random, were found respectively to give but 27, 24, and 23 per cent. of light when compared with the London standard burner; and such burners, I fear, are but too commonly found. These experiments exhibit the causes of the complaints we so often have, that consumers get but little light, when we know we are supplying gas of good quality. The matter of burners is, I think, one on which gas companies and managers may often advise their customers with reciprocal advantage.

Here I may call your attention for a moment to some remarkable papers which have been published by Mr. Pole, the last appointed London gas referee, "On the Theory of Gas-Burners," and also to the discussion on what is called Farmer's theorem.

The discovery, if we may call it so, has, you may remember, been claimed by another experimenter in America, but I believe it will always continue to be known as Farmer's theorem. The proposition laid down by Mr. Farmer, and supported by Professor Silliman, is that the illuminating power of a gas-flame (within certain limits of combustion) varies as the square of the quantity of gas consumed. The truth of this proposition, I may say, was not well sustained by the recorded experiments of Professor Silliman and of Mr. Farmer himself, and it has been conclusively demonstrated to be inaccurate by the experiments of our colleague, Mr. Charles Hunt. Now, although the theorem of Mr. Farmer has been shown to be untrue, the fact remains that the law of simple proportion, by which we always calculate our illuminating power, holds good only within certain limits. In a rough sort of way we have always known pretty well what these limits were, and have also known that they vary with every kind of burner. We have all been aware, for example, that the maximum amount of light was obtained when the flame was on the verge of smoking, and that small variations of consumption below this point made but little difference in the amount of light, in proportion to the quantity of gas consumed.

In what I may call the luminous papers of Mr. Pole, a scientific expression has been given to this well-known fact. By a process of reasoning which could only occur to a highly trained mathematical mind, Mr. Pole has arrived at the conclusion "that during the normal state of action of a gas-burner the light given varies directly as the consumption, *minus* a constant quantity." The principle involved in this law, as laid down by the author, is unquestionably sound. "When the quantity of gas supplied to a burner is very small compared to its normal capacity, it is burnt to a disadvantage, having an excess of air; it is, in fact, in the position of a Bunsen burner. Hence, as has been often explained, the deposition of the light-giving particles is impeded, the flame burns blue, and the light developed is smaller than is fairly due to the gas employed. But as more and more gas is admitted this defect tends gradually to remedy itself, until a point arrives, where a normal and proper condition is reached, and beyond that point every increment of gas gives a corresponding and uniform increment of light." There is, of course, a point beyond which gas is consumed to no useful purpose; but that is equally excluded from what has been properly termed the "normal range of a burner."

I may just mention here that the theory which Mr. Pole, and I may add nearly everybody else, assumes to be true—namely, that the luminosity of a gas-flame depends upon solid particles detained for an instant in a state of incandescence—is questioned by Dr. Frankland and others.

It would lead me too far from my present object to go into this question, but I may just mention that the experiments of Dr. Frankland have shown that the flame of hydrogen gas, which we all know is barely visible when burning under ordinary atmospheric conditions, becomes much more luminous when that gas is burned under great atmospheric pressure. This observation will not be forgotten, and in a coming age, when all our coal is exhausted, the "coming race," with perfected mechanical contrivances, may possibly illuminate the earth by means of pure hydrogen. In the meantime, nothing is more certain to us than that the luminiferous power of gas depends, first, on its chemical quality—that is, on the amount of carbon it contains; next, upon the heat of the flame, which depends on the amount of air supplied in combustion; and, lastly, upon the time the particles of carbon remain in a state of incandescence, which depends upon the pressure at which the gas is delivered for combustion. In this statement, I think, we have the theory of gas-burners complete.

To return for a moment to Mr. Pole, I think you will admit with me that he has given ample proof of the conformability of his new law with the most reliable published observations, and you will join with me in the hope that we may soon have a fuller and clearer illustration of it from original experiments.

I pass now to a brief notice of some novelties in manufacture and apparatus which have been lately introduced. The first I may refer to is one to which public attention has recently been called, but which, so far as I know, has not attracted much notice from gas engineers, nor has yet received any considerable application. I allude to the so-called improvements in the manufacture and purification of gas by Dr. Eveleigh. These I find described in the specification of a patent taken out in the early part of 1869. Some further improvements have since been patented, but the specification of these is not yet accessible. The improvements so far as they relate to the manufacture and purification of gas only, according to the specification of 1869, may be described in a very few words. Gas is first made in an ordinary retort, and is then passed through a series of what are called redistillation retorts. These are vessels set vertically in a furnace; they are packed the greater part of their height with charcoal and lime in small lumps, and at the top is placed a layer, one or two inches thick, of iron filings or turnings. The first of the series is connected with a reservoir of creosote, oil, or petroleum, and (proceeding according to the specification) when the flow of gas from the retorts slackens, the liquid substance contained in the tanks is gradually admitted to the redistillation retort, now sufficiently heated, with a result apparent enough. How far this is anything more than a caburation process on a large scale it is impossible for me to say. It may be that if the retorts are sufficiently hot, and the vapour formed is detained for a short time under pressure, some decomposition of the vapours may take place. But from all we know of the changes which happen under such circumstances, and unfortunately they have been but little studied

(Berthelot, a French chemist, has exposed naphthaline and other hydrocarbons to high temperatures and great pressures with the result stated, and Mr. Young, jun., of Bathgate, has distilled heavy oils under pressure to obtain lighter), we may suppose that only other liquid hydrocarbons are produced which may be expected to condense when the gas has cooled, or before it has travelled any great distance. The process, it occurs to me, has a certain resemblance to the inventions of Messrs. Symes and Barff, and the Rev. Mr. Bowditch, for carburetting with the heavy oils of tar. Possibly Dr. Letheby, who has recently examined the gas, may be able to give us some account of its composition. An analysis of the gas or vapour produced in the process seems to me necessary before any attempt should be made to work it on a large scale.

Many, I dare say, will have some acquaintance with the process patented a few years ago by Mr. Basford, who passed raw gas—or rather the gas as it issued from the retort—through a second retort filled with coke or charcoal. The object in this case was to break up the tarry matter into permanent gases; but the result, I believe, was not altogether satisfactory. A large amount of naphthaline was produced, and the gas rapidly lost illuminating power as it travelled. It ought to be remembered, however, that Mr. Basford used the poorest Derbyshire coal, and the results were highly satisfactory when the gas was distributed over a limited area. No process of this kind that I have yet met with appears to me workable on any extensive scale.

I do not think it necessary further to criticize this process, for, now being brought prominently before the public, its merits will no doubt be thoroughly sifted by abler hands than mine.

No other novelty in manufacture occurs to my mind at the present moment, and I pass to what I have called improvements in apparatus. One of these, which I think will have attracted the notice of every gas engineer, is the direct-action method of exhausting, forcing, and washing gas by steam, invented by Mr. Cleland, of Liverpool. I have great hopes that the inventor will be here to describe his system at length, but, if not, I would recommend to every one present the attentive perusal of a description in a recent number of the JOURNAL OF GAS LIGHTING, and also in *Engineering*.

It will there be seen that, by availing himself of the well-known action of a jet of air or vapour—which has received so many useful applications within the last few years—the inventor first of all relieves the retorts of pressure, forces the gas along its prescribed course, and, by the intimate commingling of aqueous vapour with the gas, effects, when condensation takes place, a more thorough washing than can be accomplished even by a spray scrubber. The advantages of this system appear to me obvious. In the first place, we may dispense with a steam-engine and other apparatus, expensive, and requiring much attention. Then, due regard being paid to the pressure of the steam, it appears to me that the action must be much more uniform and steady than that of the best exhausting apparatus we have at present at command. The use of the steam-jet necessarily involves some novelty in the form and extent of the condensing apparatus, which the inventor seems to have been successful in devising. Altogether I am disposed to regard this system with the greatest favour. If a quantity of steam used in the form of jets will do the same amount of work it can perform by setting machinery in action, we have the obvious advantage of getting rid of the machinery and its concomitant trouble and expense, with the additional good of an effectual washing. Before the meeting closes I do hope we shall have a discussion on the merits of this invention, which appears to me eminently to deserve the notice of gas managers.

There is one other recent improvement which calls especially for notice here, and that is the invention of Mr. Somerville relating to pipes and joints. Leakage from defective pipe-joints is, unfortunately, a thing with which we have all too much acquaintance, and few could confer greater benefit on gas companies than he who taught us how to make a sound and durable joint. Mr. Somerville is confident he has succeeded in making such a joint, and no doubt you will have the opportunity of inspecting some specimens. All I need say of the invention is that it well deserves your notice. The collar joint, which Mr. Somerville prefers, is easily made, and, as he tells us, allowed of no escape at a pressure of 95 lbs. to the inch. The saving consequent on such a complete prevention of leakage would amply compensate for some extra cost in the pipe, which, however, appears to be a very trifling amount.

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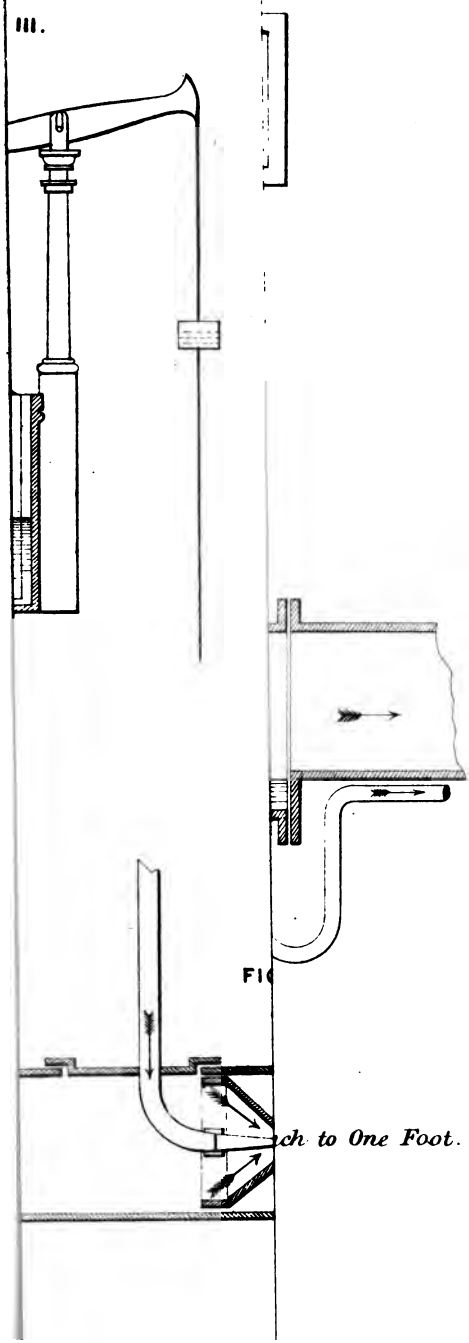

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SOMERVILLE'S PATENT PIPE JOINTS.

Fig. 1.

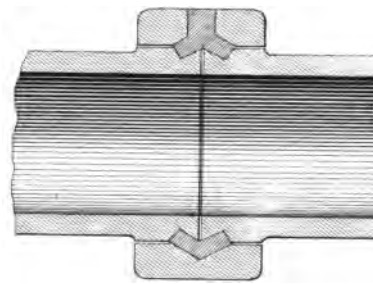
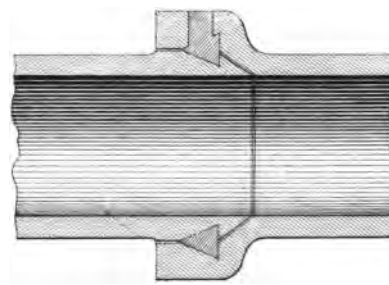


Fig. 2.



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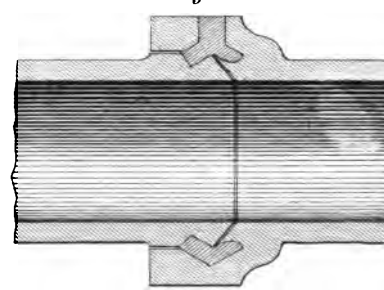

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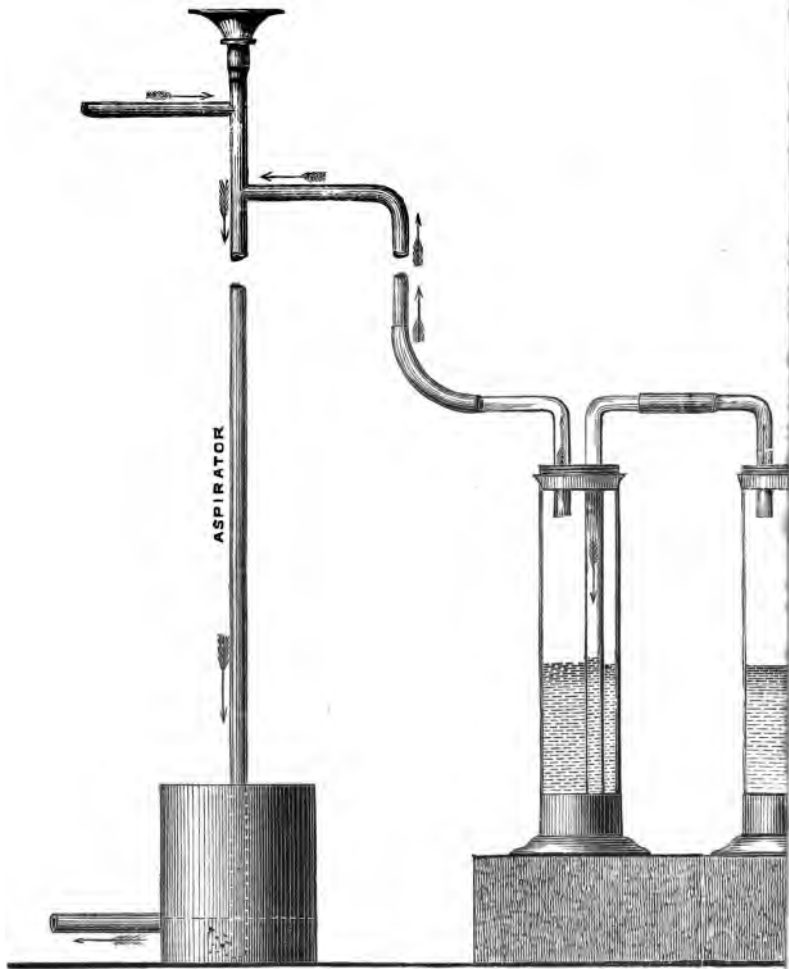

MARRIOTT'S APPARATUS FOR ESTIMATING THE AMO

In connexion with the purification of gas, I am not acquainted with any novelty which requires a lengthy notice. So far have we got in purification, that at the present time the term impurity may be restricted to a single substance —sulphur. The complete removal of this obnoxious ingredient—that is, by practicable means—for the moment baffles us, but I have great confidence that in a few years it will be accomplished. In the meantime we all know that it is possible to keep the amount of this impurity within reasonable limits. At our last meeting, you will remember, we were startled by the information that our common system of purification added to the amount of sulphur in forms other than that of sulphuretted hydrogen.

The results subsequently published in the report of the London gas referees do indeed go to show that in our purifying apparatus sulphuretted hydrogen is decomposed, and the sulphur combined with carbon to form bisulphide of carbon, or possibly united with some hydrocarbon; but, at all events, into some compound which is not removed by either oxide or lime. This statement remains at present uncontradicted, and I may add unsupported, and we must wait for the next report of the referees to see whether or not further careful researches have established its truth. True or not, however, the duty of a gas manager is clear; and, without entering upon the vexed controversy whether the quantity of sulphur commonly found in gas is or is not injurious, I think we shall all do well to strive towards the manufacture of that ideal gas, as some may call it, which should consist of light-giving hydrocarbons alone.

I have learnt with some regret that the process of purification, in part the invention of Mr. F. C. Hills, which was described to us at our last meeting by Mr. Upward, has not been found to realize the hopes that were formed of it. It certainly had the appearance of an eminently practical plan, and possibly something may yet be done to make it effective. Among other plans which have been proposed for the removal of sulphur compounds from gas, I find one the invention of Mr. A. G. Vernon Harcourt, of the University of Oxford. The first part of this process, like that of the Rev. Mr. Bowditch, consists in the conversion of bisulphide of carbon into sulphuretted hydrogen, which Mr. Harcourt accomplishes by causing the gas to pass through a mass of iron turnings of wire stuffed into the mouth of a retort after charging, and there, of course, heating to dull redness. This part of the process is no doubt effective, but difficult to apply when some hundreds of mouthpieces are engaged. The second part of the process, which is designed to remove the sulphuretted hydrogen, consists in the use of oxide of iron, suspended in water in a vessel similar to a wet-lime purifier. With this is combined a plan for the continuous purification of the oxide by bringing the liquid into contact with atmospheric air, and a further process for the production of some persulphate of iron, which, meeting with ammonia in the gas, fixes it as sulphate of ammonia, while fresh oxide of iron is precipitated to decompose the sulphuretted hydrogen. This latter part of the process is ingenious, but it may be doubted whether the whole system is applicable on any extended scale. It has been tried, I believe, to some extent at the Oxford Gas-Works, but with what result I do not know.

As it is of great importance to us to know how much sulphur is actually present in our gas, I may here refer to two processes for its estimation which have been published since our last meeting. They are to be found in the number of the JOURNAL OF GAS LIGHTING for October 11, 1870. One is a method devised by Mr. Harcourt, whose process of purification I have just noticed. This is, no doubt, a very accurate method, but it has the disadvantage to us that it requires an expensive system of apparatus, and some attention in its execution. I do not think I need describe it to you. Mr. Marriott's is a somewhat simpler plan, and I fancy just as accurate. Like Mr. Harcourt's, however, it involves the employment of an aspirator to draw the products of the combustion of the gas through the solution of permanganate of potash employed to fix the sulphur in the form of sulphuric acid. Neither one of these plans, it seems to me, offers such advantages over the simpler methods of Dr. Letheby and the London referees, as to make it worth our while as managers to adopt it. In neither case have we any assurance that we have secured the whole of the sulphur in the gas; and, while waiting for the day when some ingenious chemist shall give us a simple method of ascertaining with certainty the entire amount of sulphur, I think we may content ourselves with employing the readiest means we possess of arriving at an approximate result.

The number of new inventions I have brought to your notice is very few, but, if you look at the records of patents granted, you will see that inventors are more numerous. It is the misfortune of most of these gentlemen that they are unable to bring their inventions into public notice. Many of them may be trivial, some of them perhaps positively dishonest patents, but that is no argument against the propriety of a patent law. The advisability of such a law is now under discussion, and, speaking as I do to-day in the presence of many whose originality and experience have contributed to the perfection in the manufacture and distribution of gas at which we have now arrived, I feel bound to maintain the justice and policy of an efficient patent law.

Nothing can be sounder in principle than our present law, which is intended to reward an inventor by giving him a monopoly of his invention for a limited time. We know, however, as a fact that the original inventor is seldom rewarded, and that plagiarists and adapters often reap the profit due to originality. This may be an argument for a fuller preliminary investigation before a patent is granted, but is none against the principle of a patent itself. It is curious to observe that the opposition to the existence of any patent law comes mainly from two classes of men: some who have profited largely by patents, and some who have had to pay for the use of patented inventions. The conduct of the one class is not to be wondered at; of the other I will not speak. There are, besides, a few who profess to believe that inventors would be better rewarded in the absence of any patent law. They are, perhaps, of opinion also that property would be safer in the absence of bolts, locks, and policemen. They are welcome to their opinion; but we, who are practical men, with an existence to maintain in a world of fierce competition, may be excused for requiring guarantees against the selfish appropriation of the work of our brains and hands; and I think we may fairly join in a movement for the amendment, if you please, but emphatically against the abolition of our law of patents.

Those of you who had the pleasure of seeing the magnificent works at Beckton last year, and enjoying the hospitality of the chief engineer, Mr. F. J. Evans, will have heard with regret of the accident which destroyed one of the gasholders, which excited so much our wonder at the size, and admiration for the skill displayed in the construction. The immediate cause of the accident, which has had its counterparts in several other cases, was a high wind acting upon a gasholder which I have no doubt, under the circumstances, was too full. Whether the construction or the materials were or were not faulty, is a matter under discussion, and I dare not allude to it. But this I may say emphatically: if you have gasholders in exposed situations, do not fill them too full in windy weather.

I am approaching the conclusion of a task which I am conscious of having imperfectly performed. I console myself, however, with the reflection that, after all, the Inaugural Address is perhaps the least important part of our proceedings; our real business commences when we begin to share our knowledge, experience, and opinions with each other, by the reading of papers and the discussions which succeed. In this last-mentioned part of our business, I hope the members will exhibit no timidity. Every speaker who gives us his experience lends most valuable aid, and he who simply asks a question often elicits most useful information.

It gives me much pleasure to meet here in this city, so full of interesting associations, and destined, we may hope, to witness a reviving glory. Our sincere thanks are due to those on the spot who have made such admirable arrangements for our reception, convenience, and comfort. At the gas-works of the Alliance Company you will have the opportunity of seeing some inventions in operation which are of great interest to us. You will see the steam-stoker at work, and learn how far that machine will relieve men of the arduous and exhausting work of supplying our retorts. You will hear something of, if you do not see in actual operation, a process of obtaining gas from tar by incorporating it with coal before it is introduced into the retort. Other inventions have also been tried in Dublin, and, altogether, we must congratulate the Alliance Company, their advisers and officials, on the enterprise displayed in the management of its affairs, and the attempts at improvements they have made. You will join with me, too, in wishing them well out of their present trial—a subject I cannot further allude to.

The proceedings were then adjourned.

The first business at the afternoon sitting was the appointment of scrutineers of the votes for the election of the committee for the ensuing year.

Mr. Longworth and Mr. Hutchinson, jun., were unanimously appointed scrutineers.

The PRESIDENT stated that the committee had received a telegram from Mr. Paterson, expressing regret that, owing to pressure of business, he was unable to attend the sittings of the association, and that from the same cause he had been unable to prepare his promised contribution on the "Lithology of Gas Coals."

REPORT OF THE COMMITTEE ON SUNDAY LABOUR IN GAS-WORKS AND THE ESTABLISHMENT OF A BENEVOLENT-FUND.

The HONORARY SECRETARY read the following report of the committee, to whom, at the last annual meeting, the consideration of these two subjects was referred:—

London, June 5, 1871.

To the President, Committee, and Members of the British Association of Gas Managers.

Gentlemen,—At the annual general meeting held last year, the question of establishing a benevolent-fund, which was introduced upon the motion of Mr. Warner, and during the same sittings the reduction of Sunday labour, which was discussed in consequence of a paper read upon that subject by Mr. Morton, were thought fit matters for reference to a committee, who were requested to report thereon. This they beg to do as follows:—

Your committee's first endeavour was to ascertain the feeling of the members individually on both these subjects, and with this view a circular was prepared embodying the resolutions your committee had come to, and appending questions to which you were asked to reply.

A copy of this circular was sent to every member of the association.

The committee also exercised the power granted to them of increasing their number, and accordingly invited Messrs. Warner, Simpson, Methven, Eldridge, and Kelsall to co-operate with them. To this Messrs. Warner and Kelsall declined, the other gentlemen, however, responded to the invitation and afforded assistance.

With regard to the benevolent-fund, an analysis of the replies may be tabulated thus:

There were 92 replies.

To the first question: "Is such a fund necessary?"

- 40 say "Yes."
- 40 say "No."
- 3 consider it doubtful,
- 1 thinks it is,
- 2 don't know, and
- 6 give no opinion.

To the second question: "Should the subscription be voluntary?"

- 38 say "Yes,"
- 24 say "No,"
- 2 consider it doubtful, and
- 28 express no opinion.

To the third question: "In the event of your considering it desirable that a fund should be formed, what amount would you be willing to subscribe annually?"

- 1 says £3 3 0
- 1 says 2 12 0
- 8 say 1 1 0
- 3 say 1 0 0
- 9 say 0 10 6
- 7 say 0 5 0
- 1 says it would depend on the scheme,
- 2 would subscribe according to necessity,
- 13 would be willing to subscribe whatever appeared to be the usual sum,
- 9 say they would not subscribe, and
- 29 give no reply.

To the fourth question: "Do you know of any cases requiring the assistance such a fund would afford? If so, please to give particulars."

No cases are known.

From this table it will be seen that only 40 among upwards of 300 members are distinctly in favour of the establishment of such a fund, and not a single member at present appears to know a case in which help from such a fund is needed.

Under these circumstances, your committee were unanimously of opinion, much to the regret of several of them at least, that it would not be advisable to recommend to the association the formation of a benevolent-fund. They venture, however, to suggest that in case of any member needing help, application should be made to the association for assistance, when the committee might investigate the case, and if found to be one deserving of help, would no doubt head a subscription list, and send a circular, or otherwise communicate with the members generally.

Beyond this, your committee at present do not think it advisable or practicable to go, but they do not wish in any way to damp the very benevolent spirit which has prompted this inquiry, and has again been manifested in some of the answers to the circular.

In reference to Sunday labour, your committee have to report that though the number of replies to their questions is not so great as they could have wished, still with very few exceptions the answers have shown an earnest desire to do all that was practicable towards relieving the monotony of constant labour by giving the men an opportunity of spending the day of rest with their families, or of devoting it to a higher purpose.

The following table gives a general view of the nature of the replies to the questions in the circular, but without copious extracts it is impossible to convey an accurate idea of the feeling on this question:—

There were 71 replies, from which it appears that

The average Sunday consumption to the average week-day consumption is 72 per cent.

58 say that they have turned their attention to the reduction of Sunday labour.

11, judging inferentially, have not done so; and

2 make no reply to the question.

24 state that they have not found it practicable to reduce Sunday labour; while

7 have reduced it very considerably,

4 but slightly, and

33 have reduced it on the average 35 per cent.

3 make no reply.

From the consideration of these returns, your committee formed the opinion that the matter of greatest importance was to discover and place before the members some clear and definite plan, whereby this most desirable object—the reduction or abolition of Sunday labour—might be accomplished, the object aimed at being the total stoppage of work (in the day time at least) on the Sunday.

This has been very nearly accomplished by different members of the association in various parts of the country, and in different ways.

One of the chief supposed difficulties has been the want of gasholder room, but your committee are prepared to say that only to a very limited extent is this a difficulty; in fact, one case was mentioned where last winter Sunday work was stopped, in consequence of there being insufficient room for the gas had the retorts been kept working.

The real question is one of retorts. If the number of retorts in use is such as to produce rather more gas each day than is consumed, the work on Sunday may be very well suspended; but the common practice is to make rather less gas each week-day than is used, making up the deficiency on Sunday.

This plan of making up on Sunday for the deficiency of the week is manifestly wrong. It is quite enough, at any rate, to make as much gas on the Sunday as is consumed on that day, which appears to amount on the average to 72 per cent. of the week-day's consumption.

From the replies received, it seems that the great majority of managers are really anxious to reduce the Sunday labour, if some definite plan can be shown to them; and your committee consider their time and labour will be thrown away, unless they succeed in showing how it is to be done without injury to retorts, &c., and at the lowest possible cost to the company.

The following plan is the one which your committee think the most satisfactory, but they do not put it forward as an ultimatum, though they consider that if it were generally adopted much might be achieved in the right direction. But while recommending one plan, they do not wish to appear in any way to interfere with individual action; so that should any manager discover a more excellent way, let him, by all means, make it known.

It has been proved that clay retorts are not injured when left for 12 hours beyond the usual time, if the charges remain in and the lids on, the small quantity of poor gas that is made being allowed to escape from the hydraulic main, either by opening a cock or taking out a 2-inch plug, one 2-inch hole being sufficient to permit the escape of gas from 70 mouthpieces.

Acting on this, a few weeks ago some experiments were made, and are still continued at the London works, by Mr. Morton; at the Phœnix, by Mr. Woodall; at the Richmond, by Mr. Eldridge; and at the South Metropolitan, by Mr. Livesey; and your committee are happy to say these experiments have given the greatest satisfaction to *all* concerned.

The men working on the Saturday night complete their work by Sunday morning at six o'clock, when, instead of being succeeded by the day gang, the retorts remain idle until six in the evening, the charges remaining in with the lids closed, and the gas made—say, until nine o'clock—passes into the holders, but at about that time the plugs in the hydraulic mains are taken out, and the gas then being produced escapes. This causes no inconvenience whatever. At the same time the engine and the exhauster are stopped, the dampers of the chimney closed, and the fires fed with breeze—this necessary work being done by one fireman to seven or eight furnaces. For this purpose odd men may be obtained, so that every regular man who would have had to come to work at six a.m. has the day of rest until six p.m. to himself. The men leaving work at six p.m. on Saturday return at six p.m. on Sunday, while those leaving at six a.m. on Sunday return at six a.m. on Monday; thus giving every man 24 hours off every week, and consequently changing from night to day work weekly. This is a boon highly appreciated by the men, for it does away with that very exhausting 18 hours work which occurs at the change on the old plan.

When work is resumed at six p.m., the exhauster is not started until a portion of the beds are charged, which is done all round as quickly as possible, and on the Sunday evening no inconvenience is felt. The make of gas during the Sunday night is quite as great, and in some cases rather more than during other nights, owing most likely to the heats being better. This at any rate proves that the retorts are not damaged.

As to pay, your committee think that the system that regulates all ordinary manual labour should apply here—that is, that men should be paid only for the time they work.

At the works mentioned no pay is given for the Sunday to those men who do not work, and this has caused no discontent whatever, the men being all of them so thankful for the relief given. It will be seen that on one week one gang receives pay for six days, and the next week that gang gets paid for seven; while the second gang then has the six days work and pay.

Your committee would urge upon their brethren the necessity of doing all they can to alleviate the exhausting and monotonous labour of the stoker, feeling quite certain that a movement of this kind, though entailing a trifling expense to the company, is productive of so much good, that the gain far exceeds the loss. They are not quite sure that even pecuniarily, in the long run, there will be any loss at all. The Sabbath was made for man, and those who, in obedience to the Divine command to keep it holy, have at some apparent personal cost and trouble endeavoured to do so, have always received a blessing.

The committee also feel that, as a matter of justice to our fellow-men, all possible efforts should be made to give them their day of rest.

In conclusion, your committee desire to express the pleasure it has afforded them to be engaged in so good a work as both the questions entrusted to their investigation, and, in resigning their trust, express the hope that their labour in either case will not have been in vain.

G. Livesey, Chairman.

Mr. J. Church moved—"That the best thanks of the meeting be given to the committee for the elaborate report just presented, and for the careful and searching investigation given by them to the subjects referred to their consideration." In doing so, he said he was sure the importance of the questions dealt with in

the report were fully recognized by every member of the association, and that every one would readily appreciate the labour bestowed by the committee on their examination. With regard to Sunday labour, no doubt much might be done to reduce the amount, but he did not think any general rule could be laid down which would meet every case. Circumstances were so materially different at different works that it must be left very largely to the judgment of those who had the control of matters to decide what could or could not be done, in their respective cases, to give that relief to the workmen which all would acknowledge was very desirable wherever practicable.

Mr. NEWALL seconded the motion.

Mr. DENNY LANE (Cork) said he should like to be informed whether, in reference to the formation of a benevolent-fund, the committee had sought the co-operation of the gas companies as well as the managers of gas-works. If no such step had hitherto been taken, he thought it was a suggestion worthy of consideration whether the companies might not be asked to aid in the establishment of a fund for the relief of members of the profession who were reduced to circumstances of distress. The amount of property invested in the gas undertakings of the kingdom was so great, and the number of persons interested so many, that a very small contribution from the shareholders of the different companies would make a very important addition to any fund which might be raised among the members of this association. He was quite sure he could answer for several companies that, if proper applications were made to them, they would be quite willing to contribute something towards such a fund. There were many cases in which men engaged in gas-works—skilful and industrious men—had been struck down by illness before they were able to make a sufficient provision for their families, and he was convinced that the claims of such unfortunate individuals to help would be readily recognized by those who sought in gas undertakings the profitable investment of their capital.

Mr. J. CHURCH said it occurred to him that the first duty of the meeting was to pass a vote of thanks to the gentlemen who had acted on the committee, and whose report clearly indicated the large amount of care and thought they had bestowed upon the subject. This would not interfere with the after discussion of the question whether any and what other step should be taken in the matter.

Mr. WARNER thought there might be some difference of opinion with regard to the report itself. For his own part, he felt that the two subjects had not received an equal amount of attention at the hands of the committee.

Mr. J. CHURCH said it would be for the meeting to determine whether or not the committee had arrived at sound conclusions, but that thanks were due to them for their services could hardly be disputed.

Mr. D. LANE said in the observations he had offered he had no desire whatever to oppose the vote of thanks. The point to which he had referred seemed to be an important point, and he was desirous to know whether the committee's attention had been directed to it. He thought this was the proper way to raise that question.

Mr. G. ANDERSON said there was nothing wrong in so doing. Although the committee had performed an important, it was not a very arduous duty. It had been the custom of the association to include in one vote, at the end of their proceedings, their acknowledgments to all the gentlemen who had employed their energies in advancing the objects the members had in view, and he did not see anything in the present report which should induce them to depart from the previous practice of the association. The discussion of the general question might, therefore, very well proceed without any reflection upon the committee.

Mr. G. PARKINSON (Birmingham) said the only question raised by the motion was whether the committee should receive a vote of thanks for their services or not.

Mr. WARNER thought it was the duty of the meeting to thank the committee for their elaborate report on one of the subjects referred to them, but he could not agree to do so with regard to the other, for he did not think they had dealt with the question of the benevolent-fund as they should have done. On the Sunday labour question they had presented a most valuable document, which no doubt would help materially to reduce the amount of Sunday labour in gas-works; but that was an inquiry which emanated from a member of their own body, whereas the other did not, and he contended that the two subjects had not received an equal amount of attention at their hands. If the committee had propounded some plan for creating the nucleus of a benevolent-fund, the meeting

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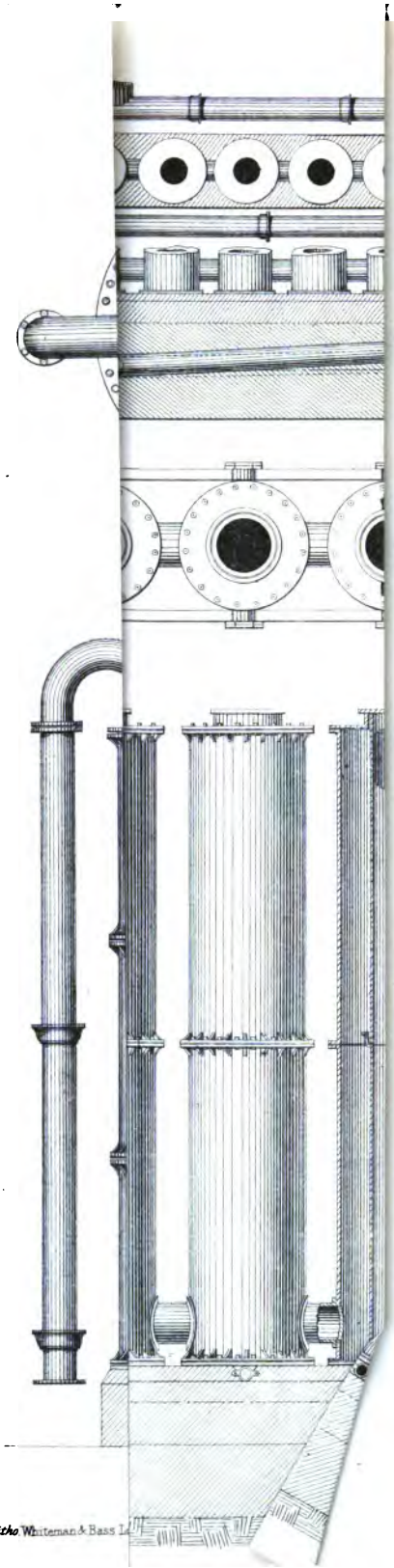

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could not have thanked them too heartily; and, considering that the association had now a large balance of funds in hand, the question of appropriating a portion of those funds to such an object might very fairly have been entertained by them.

Mr. OHREN differed with Mr. Warner on this point. The committee had not much to elaborate a report upon. Out of communications sent to 300 members, they received only 92 replies, and one-half of these were not favourable to the formation of a benevolent-fund. It appeared to him that the report fairly embraced all that the committee had before them.

Mr. SIMPSON (Rugby) thought Mr. Warner's objections were altogether out of place. As the mover of the united reference, the committee desired to have Mr. Warner's assistance, but he did not accept their invitation to attend. It was, therefore, somewhat unfair now to cast reflections upon them.

Mr. WARNER said the committee prepared a plan of their own, and issued circulars before they sent to him.

Mr. JONES rose to order.

The motion was then put, and carried *nem. con.*

Mr. J. WOOD (Bury) acknowledged the vote on behalf of the committee. In doing so, he said he felt it his duty to allude to the remarks made by Mr. Warner, and to assure him and the meeting that both the questions referred to the committee were fairly dealt with. In the one case a very large proportion of the replies were in favour of a certain course, in the other the minority were favourable to the views entertained by Mr. Warner. The committee, as representing the members of the association, were bound to report the suggestions and opinions received, and they had done so to the best of their ability. He was extremely glad that their labours were appreciated by the association, and on their behalf he expressed his obligations for the vote just recorded.

The reading of papers was proceeded with.

Mr. W. J. WARNER read the following paper:—

ON THE BEST FORM OF CONDENSER.

To no better subject could the committee have drawn the attention of this association than to "the best form of condenser." To none has so little apparent thought been given, and to no part of the manufacture of gas is so little heed paid as that of condensation. The chemical manufacture of a subtle, complex, elastic fluid, that in quantity and quality is materially affected by temperature, is carried on in many works without even the means of ascertaining what the temperature of the gas may be, and without any arrangement for controlling or regulating the same. Can there, then, after a moment's consideration, be the least surprise that such varying results are obtained in both quantity and quality, even in the same works, with the same description of coal at different periods, much less in various places, and by different men? Or what can be said for the item, "Unaccounted for," differing so in various towns, but that, while no attention is paid to the temperature at which the gas is *said* to be measured, it is like the "Fuel account" kept in some works—a snare and a delusion.

By "the best form of condenser," it is presumed that the committee meant—Upon what principle ought the refrigeration of gas to be carried on? Should it be by direct atmospheric influence, or by the intervention of another fluid? Though Mr. Lewis Thompson says little, it is believed, about the condenser, yet in a paper on Wright's "Ventilating Condenser," published in 1852, in the JOURNAL OF GAS LIGHTING, it is said, his "original and elaborate investigations have proved that while the hydrocarbon vapours contained in Newcastle coal gas at 60° have a specific gravity of 3·2, those of Boghead cannel gas are only 1·21, and in Wigan cannel gas 1·77, and that the former begin to be precipitated at a higher temperature than the two last. The safe-condensing minimum must, consequently, BE REGULATED by the nature of the material employed in the manufacture of the gas; therefore "*a perfect condenser must,*" it is added, "*allow of its cooling power being varied* according *to the temperature of the external air, and the quantity of gas passing through it.*"

In replying to the committee's circular, with list of suggested subjects for papers, it was to this point that I proposed principally to direct the attention of the members of this association in what could only be a very hurriedly prepared paper. How, then, has this principle been carried out, so plainly laid down 20 years ago? Malam had previously adopted the principle by the arrangement

of the submerged condenser, and allowing water to flow through and amongst the condensing-chambers, and so could control the temperature of the gas. Our esteemed friend, Mr. Livesey, has a condenser in operation, too, I believe, upon the same principle. Another arrangement, having the same object in view, is that of water trickling over the air condenser. The same thing was proposed to be done in another, but certainly not more simple way, though patented—the application, by mechanical means, of wetted surfaces to the condensers, and so cool by evaporation. In the annular or ventilating arrangement there is but a partial regulation, which is due, not so much to the power of ventilation proper, or a strong current of air passing through, as to the power of lessening or increasing the surface to the action of the atmosphere. Mr. Kirkham was the first to apply this principle, and Mr. Wright's is a modification, which is identical with a refrigerator patented some years previous by a brewer—connecting-pipes being employed to conduct the gas from the top of one column to the base of the next, that the gas may always enter in this order. I here take the liberty of introducing three experiments, which were published in the paper referred to.

Experiment No. 1—passing 10,200 feet per hour.
Air, 54°.—Damp and cloudy.—Covers on ventilating-pipes.

	Inlet.	Col.1.	Col.2.	Col.3.	Col.4.	Col.5.	Col.6.	Col.7.	Col.8.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
Temperature of gas	107	94	84	76	69½	64½	60	57	54½
Decrease in each column	—	13	10	8	6½	5	4½	3	2½
Accumulated effect of the successive columns	—	—	23	31	37½	42½	47	50	52½

Experiment No. 2—passing 11,120 feet per hour.
Air, 49°.—Fine and dry.—Covers off ventilating-pipes.

	Inlet.	Col.1.	Col.2.	Col.3.	Col.4.	Col.5.	Col.6.	Col.7.	Col.8.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
Temperature of gas	100	78¾	16½	59½	55½	53½	51½	50½	49½
Decrease in each column	—	21¼	12¼	7	4	2¼	1½	1	1
Accumulated effect of the successive columns	—	—	33½	40½	44½	46¾	48¼	49¼	50½

Experiment No. 3—passing 12,400 feet per hour.
Air, 55°.—Rain.—Covers off ventilating-pipes.

	Inlet.	Col.1.	Col.2.	Col.3.	Col.4.	Col.5.	Col.6.	Col.7.	Col.8.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
Temperature of gas	103	79	67½	61	58	56½	56	55½	55
Decrease in each column	—	24	11½	6½	3	1½	½	½	½
Accumulated effect of the successive columns	—	—	35½	42	45	46½	47	47½	48

It will be observed, though it may appear remarkably strange to some, that there is really no practical control over the temperature shown by these experiments; thus—

No. 1.	Covers on,	column 8,	temp. 54½,	air 54
,, 2.	Covers off,	,,	,, 49½	,, 49
,, 3.	,,	,,	,, 55	,, 55

Now, for the condenser to have answered to the principles laid down, it should have been shown that the gas could be maintained at a standard temperature, with varying makes and varying atmospheric temperatures—that the gas could be kept either below, at, or above the air. This, it is obvious, however, cannot be done with an arrangement in which the air alone, directly, is the cooling power. Before leaving this—the air condenser—I may add that Mr. Wright's connecting-pipes have been applied in duplicate, with other modifications, by Mr. Paddon; and in an arrangement of my own, I connect at the base by a short connecting-piece, and carry up a midfeather or partition near to the top of the annular chamber, and at the bottom the partition is sealed, and so there is a free way through from end to end for gas and fluids. Mr. Holmes, of Huddersfield, uses also, I believe, the partition, but I am not acquainted with the details.

In the high thermometrical absorbent power of water we have the means, and in the refrigeration of it the power to maintain the gas at any given temperature; and from the quantity of water that is used for washing and scrubbing, these two separate processes—condensing and scrubbing—may well be conducted at one operation; and with a scrubber constructed upon the principle

described at the last meeting of the association, no difficulty could arise from stoppages. In this view of the case I am considerably supported by the paper of Mr. Cleland, recently published in the JOURNAL OF GAS LIGHTING. But the idea was practically carried out long since. The first of the two new scrubbers set in action at South Shields was placed before the condensers, and though these were scarcely powerful enough in warm winter weather with the heaviest make, since the scrubber has been in action half the condensers have been thrown off, and the long connecting-pipes of the scrubber have been jacketed in, and the entire upper portion of the condensers I am now having covered in, so as to protect them from the cooling influence of frost, rain, and snow. The feed or liquor pipes I propose to arrange for refrigeration so that the temperature of the liquor may be maintained at that desired. The condensers are arranged in two sets, and may be worked either together or separate, and by means of a change-valve, which was constructed for me by the Messrs. Cockey, they may be worked from either end, and so under exhaust or pressure—that is to say, we can exhaust either through the condensers or directly from the retorts—an arrangement which we have occasionally found exceedingly useful. Upon some future occasion I may take up this subject again, and give the association what notes I may have upon it, and upon the relative positions of the condensers.

A good thermometer is much needed for condensers. That of Mr. Parkinson is a very neat arrangement, but the metal case does not stand well; the case would be better, too, if it were connected by a non-conducting plug instead of a metal one screwed into the condenser, and elastic; also if the conical metal plug of the thermometer were of a non-conducting substance.

I must now apologize for the very poor dish I have served up to you at this repast, at which there is such an abundance of good and nourishing fare.

Mr. G. ANDERSON said the condensation of gas was of course as necessary as that of whisky, which required to be brought down from the temperature of the still to that at which the liquor was used. He had found in his experience that the condensation of gas should take place progressively from the temperature of the retorts down to the temperature of the purifiers, and that it should not oscillate between them. The next consideration of importance was that it should not fall too low—perhaps not below 55° or 60°—and that any arrangement which protected it from the influence of frost was a good arrangement. A third point, not touched upon in the paper, was also worthy of consideration—viz., that it was improper to convey the warm gas immediately into the condenser exposed to atmospheric influence or that of cold water. This he stated upon his own experience, and that of others. He found it best to begin his condensation by passing the gas through a pipe, which ran round the inside of the retort-house. This pipe was supported by brackets, which extended through the walls of the retort-house, and supported an external pipe along which the gas was afterwards carried. Its further condensation was then a very simple process. He was connected with two works, one which had been in operation forty years, and the other only five or six. In the former, they were sometimes troubled with depositions of naphthaline; in the latter, where the arrangement just referred to was adopted, of internal and external pipes in connexion with the retort-house, they had never known what naphthaline was. This he regarded as a very important matter, because where there was a deposition of naphthaline, not only was there the loss arising from the removal of carbon out of the gas, but also the trouble and cost of clearing it out of the pipes.

Mr. HODGSON JONES thought the effect of carrying the pipe round the exterior of the retort-house, as explained by Mr. Anderson, would be disadvantageous, as tending, rather than otherwise, to the deposition of naphthaline, unless it were in a trough of water. For a long time he had adopted the plan of carrying a large pipe round the inside of the house, for the purpose of gradually bringing down the temperature of the gas, and he had found it absolutely necessary, in warm climates, to adopt the practice of putting the condenser inside the house.

Mr. ANDERSON (Bath) said he had a condenser like that spoken of by Mr. Warner, but, being troubled with naphthaline, he asked his directors for increased condensing power. In carrying out his arrangement with that object, he erected a wrought-iron pipe 18 inches in diameter, and ¼ inch thick. This pipe, which was 100 yards in length, was laid upon girders entirely round the interior of the purifying-house. It was his belief that, to keep down naphtha-

line, the gas must not be cooled too rapidly. He had 12 pipes to his condenser, 6 of which were washed inside with ammoniacal liquor of 6° Twaddle, and he always took care that the crude gas was not of a higher temperature than the liquor employed, because if it were so, the ammonia was extracted from the liquor by the gas. The exterior of the condenser was shielded from the sun by a tarpaulin, over which a stream of cold water flowed, because, being ¼ inch thick, the pipes absorbed a great amount of heat. The gas then passed through two scrubbers, where it was washed with liquor of 6° Twaddle. Afterwards it passed through the washer, care being taken to keep up a perpetual motion of cold water. He was proud to say that he had not cleaned out his gasholders for twelve months, whereas previous to adopting his present plan he had to examine them every three months.

Mr. WARNER said he had adopted the plan spoken of by Mr. Anderson, of carrying the crude gas round the retort-house, and he believed most gas managers had done the same. From inquiries made at the Liverpool works, he ascertained that Mr. Cleland's arrangement answered exceedingly well. His process of cooling the gas was somewhat analogous to the ammoniacal liquor pouring down through the scrubbers. Of course the temperature of the liquor was entirely under control, and the cooling of the gas was progressive.

Mr. CHURCH remarked that many present were aware of the improvement effected by the system referred to by Mr. Anderson, of carrying the pipes round the inside of the retort-house. There was one point in regard to condensation which had not been mentioned, and which it was desirable to keep prominently in view—viz., the importance of keeping the gas and tar in contact as long as possible. He believed it was the best mode of preventing the deposition of naphthaline, and, as far as his experience went, there was no better way to improve the quality of the gas. By carrying a pipe round the retort-house, as suggested, that temperature was preserved which was most calculated to retain the tar and gas together.

Mr. PHILLIPS (St. Alban's) had tried almost every description of condenser, and found the system in use at his present works the most effective. The pipes were carried all round the house, then through the middle, and afterwards there was a coil of pipes underground, the length of which he could vary by means of valves. Since this plan was adopted, he had never been troubled with naphthaline, and the quality of his gas generally had been improved.

Mr. R. H. JONES said at the new works at Dover the pipes were carried outside the retort-house on the sunny side. The two works in that town were a couple of miles apart, but were married by a main. At his private house, which was situated midway between the works, he could always tell, by the illuminating power of the gas, whether the supply was from the new or the old station.

Mr. D. LANE said that Mr. Lewis Thompson pointed out the necessity of avoiding over-condensation as well as under-condensation. He stated that at the ordinary temperature at which gas was consumed it carried with it a certain proportion of hydrocarbons, which would be condensable at a lower temperature. Those hydrocarbons had a specific power to hold naphthaline in mechanical suspension. If the temperature was too high more naphthaline left the condenser than the other hydrocarbons had power thus to retain. On the other hand, if it was too low, the result was that the other hydrocarbons themselves were also condensed, and the naphthaline could no longer be held in suspension. Every gas engineer who had had much experience was convinced of the fact that the longer the gas was kept in contact with the tar, the freer would it be from naphthaline, and the higher its illuminating power. The remark made by Mr. Warner respecting the mode of regulating temperature had not been sufficiently noted. It appeared well worthy of consideration whether some automatic arrangement could not be used which would keep the gas up to a certain temperature. With the condensers at present used the gas varied very much in temperature, according to the season of the year. There was surely some particular temperature which was best calculated to prevent the deposition of naphthaline, and retain the highest illuminating power of the gas. In none of the condensers he had seen was there any real automatic arrangement of the kind designed, and gas managers would do well to direct their minds to the subject.

Mr. HARTLEY (Westminster) said Mr. Warner had expressed a wish to have a non-conducting thermometer which should not take the heat from the con-

densers. It seemed to him that this was a matter very easily accomplished. Nothing more was necessary than to plug the column with a block of wood, and interpose a medium which would prevent the thermometer taking the heat from the metal.

Mr. WARNER said he had adopted that plan, but it was always failing. He did not know whether the members had seen Mr. Parkinson's arrangement, which was an extremely neat one. First of all, there was a very thin casing of white metal soldered to the screw-plug screwed into the condenser itself. The plug which went into the condenser had a ground conical seating for another plug to fit into, so as to make an air-tight joint. To this cone there was attached a thermometer, which, when placed in its position, was, of course, excluded from external air, and conveyed the temperature of the gas through the metal casing. He had given this arrangement a long trial, and had found it very useful.

Mr. JOHN SOMERVILLE (Dublin) read the following paper:—

ON THE CAUSE AND PREVENTION OF CHOKED ASCENSION-PIPES.

There is hardly any matter in the daily routine of a gas-work which causes so much trouble and annoyance as stopped ascension-pipes. They are a constant source of anxiety in the retort-house, as they are also a constant source of expense and waste, and happy should be the man who can say he is not much troubled with them. We know there are such cases, but they are rather the exception, not the rule. Where iron retorts are employed, and where cannel coal is largely used, the stoppage of ascension-pipes is almost unknown.

When coal is distilled in hot retorts—that is, retorts at a bright red heat, which is the best heat for the economical production of gas—towards the end of the charge the gases are given off at a much higher temperature than at the first part; this high temperature is communicated to the ascension-pipe by the gases, by transmission from the mouthpiece and by radiation from the brick-work of the bench, and all the condensation which ensues consequent upon a change of temperature from the retort to the ascension-pipe, as it flows down the interior of the pipe, is robbed quickly of its volatile properties, while the carbonaceous part of the condensation as quickly adheres to the surface of the heated iron and accumulates, which, when once formed, collects rapidly, as every addition to its thickness acts as a conductor of heat, until it soon closes the pipe, requiring the application of the auger to force a passage; and soon even that ceases to have effect, when chisel bars must be used from the top while the retort is laid idle.

We are all familiar with the fact that in a setting of seven retorts, the centre one directly over the furnace, which is usually the hottest, is always the one to give the most trouble by the frequent stoppage of the ascension-pipe. This is partly avoided in some works by charging the middles every four hours, while the others are charged every six; and when circumstances will admit of this being done, it is the best method of robbing the retort of its excess of heat, and thus preventing in a great measure frequent stoppage.

The accumulation of carbonaceous matters are deposited in a very uncertain manner, not always in the same place—sometimes near the mouthpiece, sometimes in the dip-pipe, another time in the H or bridge pipe, but generally half way up the ascension-pipe, opposite the top row of brickwork of the bench downwards to the mouthpiece; and in the case of double or through retorts, with two ascension-pipes, the stoppage takes place in one of the pipes only, then in the other, and thus alternate with every change of wind.

There are some substances which it is nearly impossible to distil for gas-making without choking the ascension-pipe in a short time, whatever precautions may be taken—such as Trinidad bitumen, cotton-seed pitch, and materials of that class, which, as soon as subjected to a heat proper for their decomposition into permanent gas, give off their gases so rapidly, which on arriving at a slightly lower temperature condense so quickly, that it is found almost impossible to use them, owing to the frequent stoppages of the ascension-pipe, or to distil them at such a temperature that it is questionable whether they are converted into gas at all; but as this class of material is not very generally used, and for the reasons given not likely to be, they may be dismissed from our consideration.

Various expedients have from time to time been resorted to, in order to overcome or prevent stoppages in the pipes; but none, as far as I am aware, have

been completely successful. We are all familiar with the plan of placing a few shovelfuls of wet coal under the ascension-pipe before closing the lid after charging the retort, or placing there an iron vessel filled with water, or an old scoop or piece of iron placed between the brickwork of the bench and the troublesome pipe; and probably some of us may have tried the suggestion, published some time ago, of adding to every charge so many pounds of rock salt or so many pounds of soda. Some of these may do no harm, but effect as little good. They are troublesome at the best, and the pipe will continue to stop after all these means have been tried. Some method of keeping the pipes cool (as the whole source of the evil under consideration is hot pipes) becomes the paramount desideratum in preventing the nuisance.

To prevent the radiation of heat from the brickwork of the bench, the transmission of heat from the iron mouthpiece and the prevention of the flame acting upon the pipe during the time of drawing and charging are the three means to be employed for prevention and cure.

First, with regard to the radiation from the front and top of the bench. Retort-benches should be built up from the foundation, having a front wall at least a brick and half thick, and having three rings of brickwork forming the arch, four courses of brickwork above the rings, then 6 inches of fine sand, and paved with brick on edge well grouted in. This will effectually prevent radiation, both to pipes and hydraulic main, and enable workmen to walk about without burning the soles of their shoes; it also conduces to a saving of fuel by retaining the heat within the bench for the benefit of the retorts instead of its being wasted in the atmosphere.

The iron mouthpiece attached to the clay retort, whether by socket or flange, should not be less than 15 inches deep, having the socket for ascension-pipe as near the front as possible, leaving at least 6 inches between the pipe and the brickwork. The mouthpiece should be cast as thin as is consistent with strength and durability, and the ascension should also be as thin as possible, half an inch thick being quite sufficient, and should not be less than 6 inches internal diameter for the regular-sized retort of 10 feet long and 15 inches diameter, for shapes, whether ⌂ or oval, having the same superficies. This size should be continued through the H-pipe to its down-leg, and then may be contracted to 4 inches with a 4-inch dip-pipe passing into the hydraulic main, and the dip-pipe should not be less than 6 inches clear of the bottom of the main.

The hydraulic should be raised at least 3 feet from the top of the brickwork, and should be of a square shape, as giving more area than a round one at the bottom for any accumulations that may be deposited, and the action of the gas issuing from the dip-pipe tends to send any deposit into the angles instead of remaining directly under the dip, as in a round or U shaped main.

A shield, fender, or flame plate is also a great protection. This should be made of 8 or 10 gauge sheet iron, and placed above the mouthpiece, and resting on them, and cover the width of pipes and be four or five feet high, and held at an angle of 35° from the ascension-pipe. This deflects the flame from the pipe during the process of drawing and charging, and also establishes a current of air through and among the pipes.

In my experience these are the best means and arrangements for preventing, as far as possible, the choking of ascension-pipes. A plentiful current of air circulating freely through and among the H-pipes and along the hydraulic main from opposite openings in the walls of the retort-house, prevents stoppages in the H or dip pipes, and also prevents the tar getting thick in the main. So that retort-houses should always have abundance of openings in the upper parts of the walls.

Doubtless, if ascension-pipes were cast double, or having a jacket surrounding them with a constant circulation of water or air from top to bottom, that stopped pipes would be unknown; and also if a piece of non-conducting material, a foot in length, attached to the mouthpiece and the ascension-pipe leading from it, could be introduced at moderate expense, it would tend greatly to diminish the transmission of heat from the one to the other.

I have been induced somewhat hurriedly to throw these remarks together, more for the purpose of eliciting discussion on the subject than from the consciousness of conveying anything original to the members of the association, feeling at the same time convinced that the matter is one of sufficient importance to engage the attention of gas managers, if only for the purpose of ameliorating the arduous duties attached to the retort-house, of improving the

temper of the stokers, and in causing their asseverations to be somewhat milder against stopped ascension-pipes.

Mr. Hodgson Jones said he had had to deal with a great many works in which the disease of stopped ascension-pipes had become chronic, and he had never failed to provide a remedy. At the present time he had about thirty gas-works under his hands, and hardly such a thing was known in any of them. The means he adopted were somewhat similar to those which Mr. Somerville recommended. He had usually found the evil arose from the fact that at some point in the old works there was an undue pressure thrown back upon the retorts at different times, and the means employed to overcome the evil was to give plenty of way to the gas to get freely off from the retorts. He had used for this purpose a 6-inch pipe at the bottom, reduced to 4 inches at the top, with 10 inches clear space from the front of the beds to the ascension-pipes, and about 3 feet to the inside of the arch, with another 2 feet to the support of the hydraulic main. He might mention that the 6-inch pipe was one commonly in use—simply an angle bend falling in the direction of the retorts; where in one or two cases they had been fixed by error in the other direction he had had stopped pipes, but the moment they were reversed the evil ceased. Another precaution against stopped pipes was to have varying levels for the tar, and never to put more than four beds on the hydraulics, so that the level of the tar might be adjusted to the level of the dip-pipe.

Mr. Warner thought Mr. Somerville had properly hit off all the essential points. One of them—that of the importance of a larger surface at the bottom of the hydraulic—was a very happy thought, and was so very simple an expedient, that it was a wonder no one had ever thought of it before. He had never himself seen it carried out, but he thought it ought to be. Again, with regard to Mr. Somerville's non-conducting connexion between the mouth-piece and the ascension-pipe, there did not appear to be any difficulty in carrying out the arrangement, and it was one well worthy of a trial. There was one thing Mr. Somerville might have touched upon in speaking of stopped pipes, and that was not the arrangement of the apparatus itself, but the working. He thought this had something to do with it. If charges of small coal were thrown into very hot retorts, so as to give them a light centre charging, the hot gases came over very quickly, and carried with them a large portion of small coal into the ascension-pipe.

Mr. Baker (Limerick) said he believed the evil of choked ascension-pipes was greatly owing to the dip-pipes not being of the same length, and therefore being differently sealed. This often occurred in old works where, when new beds were set up, there was not the same dip. The draught was greater on those retorts which had the longer dip, and the heated air drawn from the surface of the retort into the retort itself heated the gas very highly. For his own part he did not know what it was to have a choked ascension-pipe. He had followed the plan of dividing his beds at the back of the hydraulic main—*i.e.*, he had three lengths of hydraulic main divided by diaphragms, so that the liquor shall just flow over the surface. At the back of each he had inserted a valve, and when the beds were set to work by turning a screw the valve sank down. The normal seal was 4 inches, and this he reduced to 2 inches—every bed not at work he sealed at 4, and every one at work at 2 inches. He was very careful to set the dip-pipes at the same level, chipping off the lower edges of some so as to make the seal in every case the same. In an old retort-house he had found that with the variation of a quarter of an inch the ascension-pipes choke very much. If it were not for this precaution, as he worked at high temperatures he would often experience the annoyance now under consideration. As it was, he was enabled to make a large quantity of gas of good quality, and to escape the trouble with which the paper dealt.

Mr. Church said if certain well-known principles were carried out, choked ascension-pipes would be unknown. He took it that the essentials were large ascension-pipes and a large hydralic main, the former placed at a greater distance from the brickwork than had usually been done. With reference to the form of the hydraulic main mentioned by Mr. Somerville, he thought much might be said in its favour. He had himself used hydraulic mains, not quite square but rectangular. They were rather more expensive than round, but this was not of much consideration in constructing works. With attention to these details gas managers need not be much troubled with choked ascension-pipes. It was entirely a question of temperature and size.

Mr. OHREN said at the last meeting of the association he stated in his address that at the Crystal Palace District Gas-Works they had had great difficulty with their through retorts. They found, on one occasion, that the pipes were stopped on one side, while those on the other were passing gas; and, on examination, it was discovered that there had been a sinking on the former, which had increased the seal of the dip. He thereupon introduced a system for regulating the level of the water in the hydraulic main, and equalizing it on both sides, since which he had had no stopped pipes. He took out a patent for this process, but had not done anything with it.

Mr. G. ANDERSON said his experience was that it did not matter what was the size of the pipes, for under certain circumstances and conditions they would always become stopped. He had had 7-inch pipes stop as well as 4-inch. He believed it was a matter of heats only, and that size had nothing to do with it, for whatever the size might be, it was simply a question of a longer or shorter time being required before the pipes became stopped. There was great force in what Mr. Baker said, and he (Mr. Anderson) made a similar statement at a previous meeting of the association. By over-working the exhauster, if the retorts were at all out of order, the air would be drawn from the interior of the furnace, and hot air would be sent into the interior of the retorts, which might contain enough oxygen to effect combustion. He had seen 10 feet of pipe completely blocked up with a mass of carbon, in the interior of which were holes containing pure soot. He contended that this pure soot could not have got there except by the action of combustion. Care must be taken that the level of the water was equal on each side, and that the exhausters were worked at such a vacuum that no risk would be run of drawing hot air into the pipes. A year or two previously he had to remodel some works in Ireland, and not wishing to incur more expense than necessary, he adopted the existing 3-inch pipes, although he considered them too small. Experience, however, had shown that they were sufficiently large, and confirmed his belief that it was not a question of size at all, but of heats.

Mr. G. ANDERSON read the following paper:—

ON THE BENEFITS ARISING FROM THE USE OF EXHAUSTERS.

When gas was first introduced into these islands for lighting purposes, both chemical and mechanical science were so little understood that exhausters were not felt to be necessary. At that time gas only superseded whale oil and tallow candles, neither of which were salubrious or satisfactory lights.

Although the gas was not very pure, it gave a better light than these substances, and being mostly employed out of doors for street lighting, or in workshops, its impurities were not much felt; but as it got introduced to the dwellings of man, and there had to compete with the finer oils and wax candles, its impurities would become intolerable, and this would lead to its improvement or better purification.

But this extra purification cannot be effected without increasing the pressure within the pipes and also the retorts. Again, the Scotch, who have been the greatest pioneers in gas manufacture, discovered that earthenware retorts were better for their purpose than iron ones (which were the first employed); but as earthenware is more porous than cast iron, the pressure within the retorts caused them to leak a considerable quantity of the gas, and I have known earthenware retorts abandoned and cast iron ones resorted to again for this cause alone.

But the immediate cause which led to the introduction of exhausters was the large amount of carbon which Mr. Grafton found to form in the interior of his retorts, which led him to make a number of experiments, because, as he states, "after consulting the most eminent scientific authorities," they did not, to his mind, satisfactorily account for the evil. As I think it will be interesting to many gas managers to have these experiments described, I will quote Mr. Grafton's own language.

Mr. Grafton says: "After a series of experiments, established in 1839, at the Cambridge Gas-Works, and after having in vain offered a large premium for the discovery, I was myself enabled to detect the origin of the great accumulation of the carbonaceous deposit in coal gas-retorts, as well as the means of obviating an evil which has been the source of so much loss to the manufacturers of gas. Previously to that period the most eminent scientific authorities consulted on the subject considered this accumulation as the result of high degrees of heat, and too great an extent of heated surface.

"To ascertain how far this opinion was correct, I commenced my experiments with a number of retorts reduced to various lengths, by the ends being filled up with brickwork, the other dimensions remaining unaltered.

"By this difference of length, after repeated trials and at various temperatures, the deposit did not appear to be diminished, although it did not accumulate so rapidly, and finally it formed a coating of the same substance, not less in a short retort than in a long one.

"It was observed in all cases that the substance began to form itself first at the closed end of the retort, whence it gradually advanced, and accumulated in bulk; at that end the coal (especially with cylindrical iron retorts) is carbonized first. Hence the inference is that the best constituents—viz., the hydrocarburets—being without the means of escaping, become decomposed, leaving as a result the carbonaceous deposit.

"I then had two retorts constructed, with an ascending pipe to carry off the gas at each end, so that its stream might divide itself into equal portions each way, thus reducing the passage over the heated surface from 7 feet (the length of the retorts) to 3 feet 6 inches, and affording equal means of escape to the gas from all parts of the coal. The deposit, after three months constant working, was considerably less at the closed end of the retort, but it formed itself in the same quantities on the roof, and soon covered the whole of the inner surface, gradually, as heretofore, diminishing the capacity of the retorts, and increasing the consumption of fuel.

"The resistance offered to the gas during these experiments by the purifiers and the weight of the gasholders was equal to a column of water of 9 inches by the gauge on the mouthpiece, this pressure having varied by the alteration of the weight of gasholders between winter and summer. I remarked that the accumulation was not so rapid in the summer months, when the resistance was less and the gas less compressed. I immediately had the pressure increased to a column of 14 on the gauge, keeping up the usual heat. The retort for this experiment, like all the rest, was constructed of fire-bricks of the oven form—7 feet 9 inches long, 5 feet wide, and 16 inches deep—capable of holding and carbonizing 130 lbs. of coal every hour, or 7 cwts. in six hours. At the end of the first week the deposit appeared about an inch in thickness, and when once formed it accumulated more rapidly, till the whole inner surface within a foot of the mouth was covered with it. At the farther end it rapidly filled up the retort, preserving an equal thickness, until, at the expiration of two months, it had reached 24 inches in thickness, stopping up the retort quite one-fourth of its length; under the roof and upon the sides of the remaining portion of the retorts, it formed a coating of not more than 2 or 3 inches thick; in four months more it would have filled up the whole.

"We then had the substance cut through into two parts and taken out, when, after allowing for some of the scattered fragments, it weighed full 10 cwts. 24 lbs. The coal carbonized, during the time of this experiment, was 67 tons of Woodside Wallsend—the same having been used in nearly all the former trials—the deposit, therefore, was in weight about $1\frac{3}{10}$ per cent. of the coal carbonized, *and undoubtedly occasioned by the compression of the gas in the retort* immediately after its formation.

"I have applied myself to the means of taking off the whole of the pressure, which I effected, excepting only the resistance offered by the half-inch dip in the fluid of the hydraulic-pipe, under this change of operations. After the same retort was again worked with the Woodside coals without interruption for four months, I had the satisfaction of observing that scarcely any deposit appeared at the expiration of that time.

"If I mistake not, this will prove a welcome discovery to all gas companies, more especially to those where the Newcastle coal is used."

The first machine that Mr. Grafton employed for sucking the gas from the retorts was a common wet gas-meter, and to make it serve a double purpose, he made also a wet lime purifier. An exhauster of this kind I saw at the Hague some 22 years ago, but from the difficulty of getting the hoods of the drum to overlap far enough to resist high pressure, and also from the large amount of power it required to drive it, this form of exhauster never became extensively used.

It is not my intention to introduce into this paper any description of the numerous forms of exhausters, for two reasons—first, I was asked by the council to prepare a paper on the benefit arising from the use of the exhauster; and, second, because I am interested in the sale of an exhauster that bears my name,

and I do not want to make the society a medium of puffing things in which I am financially interested. I thought it well, however, with a description of the introduction of the principle, I might mention the simple, beautiful, and ingenious manner in which Mr. Grafton accommodated his means to his wants, and paved the way to one of the most important mechanical appliances that has occurred in gas manufacture.

Although the incrustation of carbon upon the interior of the retort was the fact that led to the use of the exhauster, the removal of that is by no means the chief advantage that has been found to arise.

By removing the pressure from the interior of the retorts, we are enabled to use purifying apparatus, such as washers and scrubbers, all which tend to increase the pressure; but as the exhauster is fixed between those vessels and the retorts, and the gas is sucked from the latter and forced through the former, we can have from one to two inches of vacuum on the side of the exhauster next the retorts, while there may be a pressure, as there is in some cases, of 36 to 40 inches on the other side, which, in the absence of the exhauster, would all be thrown upon the retorts.

We are also able to use heavier gasholders of the telescopic form, in which with their tanks there is a saving of 30 to 40 per cent. of money, as well as in the land employed for their use.

It also follows that retorts last much longer when the pressure is removed. When they have been at work a year or two we sometimes find a piece drop out; we repair this by putting it in again, or it may be by putting in a piece of fire-brick, and finishing with stiff fire-clay, and, as there is no pressure in the retort, this makes a good repair of a retort that, without an exhauster, might be useless, or, if not entirely so, would be so leaky as to waste a large proportion of all the gas generated in the retort.

It also follows that, from the lesser formation of carbon on the interior of the retorts, not only is there, upon an average of cases, 10 per cent. more gas made per ton of coal, but the retorts are more easily and uniformly heated, and that with a smaller amount of fuel.

It follows also that the men find it much easier to put on the retort-lids, and, when on, they are more likely to be gas-tight than where there is a strong flare, that both hinders the men and frequently blows off the luting.

On the question of money advantage, Mr. Cockcroft, the engineer of the gas company of Littleborough, favoured me with his experience of six months before and six months with the exhauster, as follows:—

Without Exhauster.

Date.	Gas Produced. Cubic Feet.	Coal and Cannel Carbonized. Tns.	Cts.	Qrs.	Av. Produce of Gas per Ton of Coal and Cannel. Cubic Feet.
October, 1866 . . .	950,400	104	5	0	 9,116
November, ,, . . .	1,475,900	170	0	0	 8,681
December, ,, . . .	1,721.900	197	12	0	 8,714
January, 1867 . . .	1,582,500	187	10	2	.... 8.440
February, ,, . . .	1,139,160	132	2	0	 8,623
March, ,, . . .	750,210	86	19	2	 8,680
Total . . .	7,620,070	878	9	0	 8,674

With the Exhauster working.

Date.	Gas Produced. Cubic Feet.	Coal and Cannel Carbonized. Tns.	Cts.	Qrs.	Av. Produce of Gas per Ton of Coal and Cannel. Cubic Feet.
October, 1867 . . .	1,123,940	114	18	0	 9,781
November, ,, . . .	1,682,290	170	18	0	 9,843
December, ,, . . .	1,946,230	198	9	0	 9,807
January, 1868 . . .	1,777,150	182	9	0	 9,768
February, ,, . . .	1,336,260	135	10	0	 9,883
March, ,, . . .	812,490	88	4	0	.... 9,191*
Total . . .	8,678,360	890	2	0	 9,744

* Exhauster not working all this month.

I need not read the whole of the figures, which in each case are given monthly, but quote you the results.

Without the exhauster, the gas made per ton of coal was 8674 feet; with the exhauster, 9744 feet—being an increase of $12\frac{33}{100}$ per cent.; and this increase would have been greater but for the fact that the last month of the six with the exhauster—namely, the month of March—the exhauster was not in action, so that we have one month of a low yield incorporated with five months of a higher yield—for instance, in the month of February, with the exhauster, the make was 9883 feet per ton of coal; whereas, in the month of March, without the exhauster, it fell to 9191 feet.

I think it better to give this explanation than to omit a month of Mr. Cockcroft's figures, but, for the purpose of arriving at the financial result, I must omit the month of March, in which the exhauster was not at work. One fact, however, I wish to point out, which, in my opinion, refers to the question of duration of retorts—namely, that without the exhauster the yield of gas was best at the beginning of the winter, and gradually became worse towards the last, the figures being—yield in October, 9116 feet; yield in March, 8680 feet; whereas, with the exhauster, we have October, 9781 feet, and February, the last month, the exhauster was, in action, 9883 feet.

To get at the financial results, I will suppose a consumption of 2000 tons of coals per annum, and the price of coal delivered 16s. per ton, from which members can make comparisons suitable to their own cases.

2000 tons of coal, with exhauster, producing 9844 feet per ton.

The average of the five months equals	19,688,000	feet.
2000 tons, without exhauster, at 8674 feet per ton .	17,348,000	,,
Divided by make per ton, without exhauster, 8674—		
Difference	2,340,000	,,
Saving	269	tons.
269 tons of coals, at 16s.	£215 4 0	

To work out the problem, there should be added the extra duration of the retorts and the advantages named, and from it there should be deducted the interest on the capital invested, and the cost of fuel and labour driving the exhauster; but, as I think that the one may be set against the other, I take no notice of either.

Another advantage of the use of the exhauster is that if 10 per cent. more gas is made from the coal, there must be a saving of that amount in the labour account for stokers, and also in the capital necessary to be invested in retorts and retort-houses.

Another incidental advantage is that wherever an exhauster is employed we can get assistance from the steam-engine in driving pumps for tar, for liquor, or for the water necessary in the conduction of the works, which often saves the men much arduous work; and from the steam-boiler we get steam or warm water to clean out pipes or keep gasholders from getting frozen in winter.

I have never known a case where the men would, of their choice, abandon the exhauster, but I have seen them use every energy to get it started again when accidentally out of action; nor have I ever known a manager of gas-works wish to do without the exhauster after he had once had one, but I have known many have them in duplicate, for fear by any accident they should be a day without its use.

I have no hesitation in stating that it is nothing but the ignorance of the parties concerned in any gas-works using 500 tons of coal in the year, or even somewhat less, if they are without an exhauster.

And generally, wherever you find such, you will find badly conducted works, badly purified gas, few private consumers, little extension of the business, small dividends, frequent change of managers, from the quarrels that bad results always occasion between managers and their board of directors, and badly paid officers and servants, who correspondingly take little interest in the success of the works. But when you have an exhauster all these things are reversed, which I trust is the case already, or soon will be with the whole of you.

In large works it is usual to have a man to look after the engine and fire the boiler, filling up his time with other duties; but in works up to 3000 or 4000

tons of coal used per annum this is unnecessary. The stokers do it among them, and the fuel required is only the refuse from the ash-pans.

In conclusion, I ask the excuse of those members who already have exhausters, and know, perhaps, more advantages than I have named. This paper is not so much for them as for others who have not advanced to that stage of experience.

Mr. MILES said Mr. Anderson had quoted a place with which he was familiar —Littleborough—but he knew of another place, similar in all respects, which had an exhauster of the kind described, and the manager would be extremely glad to use it, but he could not realize the beneficial results which Mr. Anderson spoke about. He could make, as an average for the year, 10,900 cubic feet of gas per ton of from 17 to 19 candle power, with from 40 per cent. of Wigan cannel and 60 per cent. of Wigan coal, and that, too, without the use of an exhauster at all. Perhaps Mr. Anderson could explain how this was. There was no doubt that in large works exhausters were valuable, but the question was what were the smallest works at which they could be profitably employed. He could credit the statement that by their use the durability of retorts was increased, but whether to such an extent as to counterbalance the expense of working the exhauster he doubted. It had been said that the workmen were in favour of its use. Probably that might be so when no trouble was occasioned thereby, but in cases, of which there must be many, where the exhauster was necessarily placed at 60 or 100 yards from the retort-house, and the men were obliged, at all hours of the day and night, to go and look after the boiler and engines, he could scarcely believe they would be strongly prejudiced in favour of it. He would be glad to be informed how much longer retorts would last with an exhauster than without; upon what basis it was calculated that the make of gas was increased 10 per cent. by its use, and how it could be accounted for that such results had not been obtained in the works he had mentioned.

Mr. CRAVEN (Dewsbury), in reply to the last speaker, said that, in works where the consumption of coal was from 500 to 1000 tons per annum, it would be worth while to employ an exhauster. In such a case as that supposed, where the exhauster was 100 yards from the retort-house, they must be large works, and therefore capable of profitably employing an exhauster. He had two works under his charge, and he found that if from any cause it became necessary to stop the exhauster at either end, the make of gas immediately dropped down, and it was the object of the manager to get it to work again as speedily as possible, because it was felt that the benefits of its operation were undeniable.

Mr. FRASER (Inverkeithing) said in the east and centre of Scotland there were no exhausters except in the large works, and yet in those places there were good management and good dividends, though underpaid servants. In the town of Dundee, under the old management, exhausters were used at the gas-works during the winter, but the expense was found too great in the summer, and they were then thrown out of action.

Mr. BROADHEAD strongly objected to Mr. Anderson's accusation of ignorance on the part of those who did not use exhausters. Last winter, with 86 clay retorts, he worked 74, and made from 220,000 to 225,000 cubic feet of gas per 24 hours without any exhauster. He worked at 6-inch pressure into the hydraulic, and stopped ascension-pipes he knew nothing about. During the last 20 years the works had yielded a profit of 10 per cent., and sufficient in addition to pay up all arrears since 1846, and to add recently £500 to the reserve-fund. In answer to several questions, he stated that the price of gas at Grimsby was 3s. 9d. per 1000 to the general consumers, and 3s. 6d. to the railway and dock companies, which paid upwards of £1000 a year for their supply. The parliamentary standard of illuminating power was 14 candles, but he gave 16 out of the works. All his works had been constructed by himself during the last 20 years. He realized about 8700 cubic feet of gas at the station-meter, and delivered something like 7500 feet to the consumers per ton of coal carbonized. The price of South Yorkshire coal, delivered at the works, was 9s. 2d.; his coke produced 10s. per ton, and he obtained 2s. 6d. per 100 gallons for his ammoniacal liquor. Such being the result of his working, he did not see the use of having an exhauster, and he did not consider himself exposed to the charge of ignorance while he thus continued to satisfy both his employers and the public.

Mr. WARNER said he should like to have heard, in connexion with all the statements made, an account not only of the temperature at which the gas passed away from the exhauster, but also the temperature at which it was measured, and the condition of the meters employed. Meters—especially station-

meters—were very troublesome things, and any figures might be got from them. He thought such high quantities of gas per ton of coal as had been quoted should not go unchallenged, but be accompanied with their qualifying facts.

Mr. MILES said his statement about 10,900 feet referred not to the station-meter but the consumer's meter.

Mr. R. H. JONES said his firm had three gas-works in Ireland where the consumption was from 300 to 450 tons of coal per annum. In two of these small works there were no exhausters; in the third, where the consumption of coal was the largest, an exhauster was employed; and he could state from experience, ranging over four years, that the make of gas there was 10 per cent. greater in proportion than at the other places, and this 10 per cent. had reference not entirely to the quantity shown by the station-meter, but the quantity sold to the consumers. The illuminating power of the gas was certainly better in the town where the exhauster was used than in the others, and with reference to the question of the expense of fuel used under the exhauster, he might state that they simply used the waste which came from the ashpit and a few ashes quite unsaleable.

Mr. DARNEY said the consumption of gas in Faversham was about 16 million cubic feet annually, and though he was not ignorant of the use of an exhauster, he did without one from 1860 to 1869. During that period the concern was very prosperous, paying 10 per cent., but since they had begun the use of an exhauster they had been even more so. The exhauster cost £180, and the total expense, including some necessary alterations for pumping purposes, was £230. In the first year of its use they sold 250 chaldrons less coke, but against that was to be set the fact that they carbonized 180 tons less coal; while they sold 360,000 cubic feet more gas, which, at the current price, amounted to £90, and with the saving on the quantity of coals very nearly paid the cost of the exhauster. When first introduced, he had some doubt whether his men would be able to work it. They looked upon it somewhat as an innovation and a thing which would cause them additional trouble. Now they were just as proud of it as a girl with a new doll, and kept the engine as bright as silver, and the engine-room as clean as a new pin. As it pumped the water there was less work to do in the retort-house than before, and altogether he considered it a perfect success.

Mr. CHURCH would have thought there could be no doubt in the mind of any gentleman present as to the value of exhausters—certainly there would not be with those who had had any experience in the matter. To his own mind, indeed, all that had been said on the other side rather enhanced his opinion of their value. Mr. Broadhead who, according to his own statement, had been so extremely successful without an exhauster, had only made 8800 feet of gas per ton of coal carbonized. He ventured to tell Mr. Broadhead that with an exhauster he would have made another 1000 feet. He knew many places such as Mr. Fraser had referred to, where they were working clay retorts without an exhauster exceedingly well, but he had no doubt that with its use they would show correspondingly better results. He had taken some trouble in the matter, and made several experiments to determine the value of exhausters, and had always found that 10 per cent. was about the increased quantity of gas made with any description of coal, and up to this extent there was no deterioration in the illuminating power of the gas produced. This was a very important consideration in estimating the cost of manufacture and production of gas. With reference to the size of works where exhausters became profitable or otherwise, he had found in his own experience that when the consumption of coal was about 1000 tons per annum, an exhauster might be used with profit. Probably on a smaller scale it might be so, but on that point he could not express an opinion. As to the cost of working, the foreman of the stokers where the make was from 15 to 20 millions per annum would look after the engine-house for an additional 1s. per week, and there could be no doubt the men did appreciate any machinery which reduced labour. The pumping of water in some works was often a serious expense, and the engine might be employed for that purpose. One point should be explained in reference to Mr. Fraser's remark—viz., that in the works he spoke of, cannel was used for gas-making, and there being less deposit from that material than from Newcastle coal, an exhauster was less needed. In some works in Scotland such a thing as a carbonaceous deposit was scarcely known even in ordinary short retorts, a circumstance with which he was much struck when visiting that country. All such questions as the one now under considera-

tion must be reduced to finance; and viewing this in that way, and seeing that clay retorts would last one-third longer with than without exhausters, he thought there could be no doubt of the advantage of their employment.

Mr. BAKER spoke in favour of the use of exhausters, and said at Limerick he had been using Londonderry coal for twelve months, from Earl Vane's pit, and had obtained from it 11,500 feet of gas per ton.

Mr. WARNER, interrupting, said, when the quantity and quality of gas was mentioned, he thought the meeting ought to be informed whether it was tested periodically and by a public examiner.

Mr. BAKER said the gas was tested by himself with Lowe's photometer, and was equal to 13 candles.

Mr. WARNER asked what was the temperature of the gas at the inlet of the meter, and whether there was a self-regulating water-line to it.

Mr. BAKER said there was not.

Mr. WARNER inquired whether there was a gauge for the height of the water.

Mr. BAKER said there was, and he saw after that himself. He worked high heats, and therefore could not get on without an exhauster. He had no fixed thermometer.

Mr. WARNER said he doubted whether any other gentleman present could state that he was making that quantity of gas per ton.

Mr. FOULIS said at Glasgow exhausters were employed. Referring to the remark made by Mr. Church, he said there was a deposit with cannel coal.

Mr. ANDERSON said he had very little to say in closing the discussion, as the speakers had answered each other. On the whole, the balance appeared to be in favour of those who advocated exhausters, and he had no doubt that those who were now making 9000 feet of gas per ton without using them would find a satisfactory increase of production by their employment. As to the time which retorts would last longer with exhausters, the figures which he had given were very satisfactory. And it followed really from the exercise of judgment in the matter, that, if there was no pressure inside an article, it must wear longer than with such pressure existing, especially with an article like a retort, which was in a highly heated state during the whole of its active life. No doubt Mr. Broadhead was very successful in the results he had given, but it was questionable whether any other man could do the same, and even he would have been more successful with an exhauster. Mr. Darney proved that he obtained more gas and a better money return with than without an exhauster. As to Mr. Cockcroft's figures, he took them as he found them; but he could personally confirm what Mr. Jones had said—viz., that at their own works they made 10 per cent. more gas with identically the same coals where the exhauster was employed, and the gas was of better illuminating power, and of course better purified, because they were able to use washers and scrubbers through having removed the pressure from the interior of the retorts. Perhaps he ought to apologize to Mr. Fraser for the remark in his paper that it was nothing but the ignorance of the parties concerned which prevented the use of exhausters. At all events the remark did not apply to Scotland, because there they were not so much required. When making gas of cannel coal, an ammoniacal liquor of weak quality was obtained, and washers and scrubbers were not much used, so that exhausters were not so necessary.

Mr. FOULIS said in Glasgow all the liquor they sent out was of 5° Twaddle, and would take 10 oz. of acid to saturate it. They used both washers and scrubbers.

Mr. ANDERSON said, in that case, the pressure on the retorts being increased, exhausters became necessary. Mr. Darney said the men in his employ were proud of the exhauster, and this was a point worth notice. If men could be got to take a pride in anything, it raised their moral tone altogether, and was an important step towards securing a generally improved state of things on the works.

Mr. NEWALL said he had seen the apparatus which had been alluded to at Littleborough. Before the exhauster was put up, they found the more gas they made the weaker was its illuminating power, and he thought Mr. Anderson's paper was scarcely complete, as it did not give the illuminating power of the gas under both circumstances. Even for works of the size of Littleborough, where in the summer time there were only three retorts at work, an exhauster was very useful, for it enabled them to pump their ammoniacal liquor. The fuel required was only the waste which came from the ashpit, and the men

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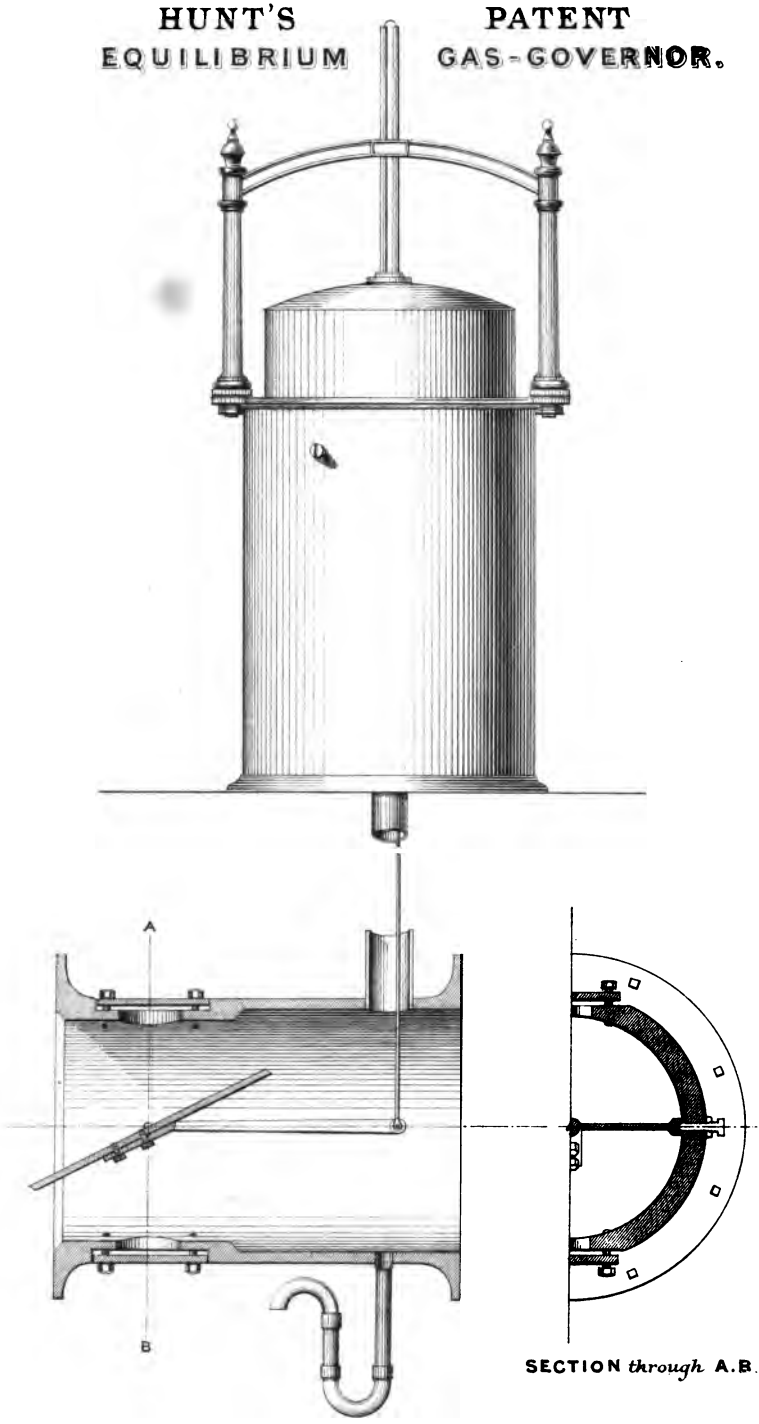
HUNT'S PATENT EQUILIBRIUM GAS-GOVERNOR.



SECTION *through* A.B.

Litho Whiteman & Bass London.

got nothing additional for attending to the engine, so that the expense was very little indeed. He quite agreed with Mr. Anderson that those gentlemen who had made large profits without an exhauster would find a satisfactory addition to their receipts by its adoption.

The Honorary Secretary read the following paper, in the absence of the writer:—

ON A NEW EQUILIBRIUM GAS-GOVERNOR.

By Mr. Charles Hunt.

The proper regulation of the supply of gas to the districts is a matter of considerable consequence in gas engineering. Before an audience such as I have now the honour of addressing, it is quite unnecessary for me to enlarge upon its advantages, or do more than observe how much the comfort of the consumer is dependent on, and the anxiety of the engineer relieved by, the satisfactory performance of this important duty. I will not, therefore, attempt to excuse myself for venturing to occupy a small portion of your time in bringing before you what I conceive to be an improvement in the means employed for effecting this desirable object.

The ordinary governor, although an advance upon the slide-valve for the purpose of regulating pressure, is yet far from satisfactory in its present forms or in its action. Apart from its size, which, looking at the gigantic proportion now assumed by gas manufacture, is not unworthy of consideration, its liability to oscillate, and its inability to maintain a uniform pressure under variations of inlet pressure, are faults which militate seriously against its practical usefulness, being fruitful sources of annoyance, and even danger.

The latter defect I believe to arise from the use of a suspended valve. There is no doubt that a gasholder in equilibrium, actuating a valve placed upon the inlet, will perfectly control the outlet pressure, provided the valve be also in equilibrium. This essential condition is not fulfilled in the case of the conical valve of an ordinary governor, where the bottom of the cone, or surface of exposure to inlet pressure, is in effect a part of the area of the gasholder, and, therefore, any variation of pressure upon it at once disturbs the equilibrium of the holder, which only a corresponding alteration of outlet density can restore. This is borne out by experience of a twofold character. It is found in practice that those governors are the most to be depended on in which the greatest difference exists between the areas of the gasholder and the bottom of the cone, or, what is almost the same thing, the connecting inlet-main; so that it follows that, in order to secure the greatest efficiency, you must magnify dimensions already far too cumbrous. Again, it is beyond a doubt that with a properly balanced valve no such fault is apparent. Every one is familiar with the action of Wright's exhaust regulator. Whatever difference of opinion may exist as to the advisability of this means of regulation—and I do not wish to be understood as advocating it—there can be no question that what it is designed to do, Wright's apparatus does very efficiently. Exposed to variations greater than any governor is or can be subject to, it is impossible not to admire the steadiness with which the required vacuum is maintained. And this is accomplished by means of a throttle-valve, which is a balanced valve.

The other defect to which I have alluded is the liability to oscillation. There can be few who are not more or less familiar with this nuisance, so apt to give rise to unpleasant complaints from the districts, and against which it often requires the utmost watchfulness to guard. It is attributable to the large area of the inlet and outlet compared with the capacity of the gasholder, which latter, in its efforts to resist the influence of disturbing causes and maintain its equilibrium, rises and falls with extreme rapidity, and thus, by alternately opening and closing the valve, occasions oscillation. Here, again, a partial remedy is found in the enlargement of the area of the gasholder; but this, although true to the principle of the suspended valve, does not find much favour, if we are to judge by the number of annular governors in use. It is also overcome by covering up the inlet and outlet pipes, leaving only a small opening for the passage of the outlet gas into the holder; but this, besides being an admission of faulty construction, is apt to render the action of the governor extremely sluggish and so far additionally unreliable. The substitution of a balanced valve, with small actuating holder, presents none of these drawbacks, and is at once more economical and thoroughly efficient.

The improvement by which I conceive I have rendered the throttle-valve

more applicable to the purposes of a governor, consists in placing the lever or radius-arm inside, upon the disc or throttle, instead of outside, at the end of the spindle, which ordinarily carries the disc. The necessity for a stuffing-box is thereby avoided; and instead of the spindle, the disc is carried by two small steel centres, upon which it is accurately balanced, and turns freely. The friction being thus reduced to a minimum, the valve is rendered extremely sensitive to variations of pressure, and a very small holder (less than one-sixth the size of those usually employed) is sufficient to actuate it. The pipe which conveys the outlet gas to the holder is connected to the valve immediately over the top of the lever or radius-arm, and thus serves to enclose the connecting-rod, all external communication being thereby avoided. Provision is made by small man-holes at top and bottom for getting at the valve, should it happen to foul with naphthaline or from any other cause.

The advantages of this arrangement are sufficiently obvious. The valve, being separate from the holder, can be handled and fixed like an ordinary slide-valve, taking up very little more space, and thus simplifying the necessary connexions to the greatest possible extent. The gasholder, which is placed at any convenient distance immediately over the valve, having little or no friction to overcome, only requires to be just large enough to work freely, and the passage of the outlet gas into it may be contracted to the smallest dimensions, thus effectually precluding the possibility of disaster from an escape such as that which occurred at the London Gas-Works a few years ago. The weight of the lever, connecting-rod, and gasholder, is balanced by an internal air-vessel, and the required pressure is obtained in the usual manner.

In conclusion, I may state that an 8-inch valve, actuated by a holder only 12½ inches in diameter, has been in successful use at the above works for the last eight months; and a second, for an 18-inch main, with holder 17 inches diameter, the original of the drawing exhibited at this meeting, has within the last few days been fixed.

Mr. HARTLEY said he had nothing to urge against the principle of the governor just brought under consideration. It certainly appeared to him to be a very excellent arrangement. He merely rose for the purpose of referring to one expression in the paper. Mr. Hunt asserted that the covering up of the inlet and outlet pipes, thus reducing the passage for the outlet gas into the holder, was a confession of a defect in construction. It really was no more so than the application of the governor was to a steam-engine. It served a purpose—to steady the instrument. In reference to the arrangement brought forward by Mr. Hunt, he had seen the apparatus in action and it seemed to do its work very well. But there was, no doubt, something in having a real gasholder, that gave a man a sensible weight to deal with. He did not know whether Mr. Hunt was right in saying that those governors were most to be depended upon in which there was the greatest difference between the areas of the gasholder and the bottom of the cone. He could only say that he had himself manufactured small gasholders with large cones, and they had been found to work admirably enough in certain conditions.

Mr. G. PARKINSON asked whether he was to understand Mr. Hartley as asserting that there was no necessary proportion between the gasholder and the cone.

Mr. HARTLEY replied, not wholly so, but that he had made them of different areas and proportions. Certainly proportion must have something to do with it.

Mr. G. PARKINSON maintained that they bore a direct proportion to each other, or should do so. It depended very much upon the weight of the cone and on the means by which the gas was admitted.

Mr. W. C. PARKINSON said the area of the gasholder should be as many times the area of the cone as it was desired to reduced the pressure.

At the close of the sitting the members of the association visited by invitation the works of the Alliance and Consumers Gas Company, in Great Brunswick Street, where they were met by Mr. Moylan, the chairman, and Messrs. Drummond and Milo Burke, directors, accompanied by Mr. John Somerville, the chief engineer.

At the close of the tour of inspection the members of the association were entertained at a *déjeuner* served up in one of the rooms of the building, which was appropriately and tastefully decorated with flags and evergreens.

The chair was occupied by Alderman MOYLAN.

After the usual loyal and patriotic toasts had been responded to,

The CHAIRMAN proposed—"Prosperity to the British Association of Gas Managers." He cordially welcomed the members to his native country, and expressed a hope that their visit would yield them unmingled satisfaction. His only regret was that on this occasion the secretary of the company was necessarily absent in London on parliamentary business, so that their reception was not so formal and becoming as he could desire.

The PRESIDENT (Mr. White), in a few appropriate observations, expressed the pleasure which he and the members generally felt in visiting Ireland, and their sense of the kind and hearty welcome with which they had been received. He concluded by proposing—"Success to the Alliance and Consumers Gas Company, and prosperity to the city of Dublin."

The toast was drunk with all the honours, and the CHAIRMAN responded.

The health of Mr. Stevenson, the secretary, and Mr. Somerville, the engineer, followed, and Mr. SOMERVILLE having acknowledged the compliment paid to him, Mr. CHARLES STEVENSON responded for his father, and the party then broke up.

At the evening sitting, the following lecture was delivered:—

ON THE ANALYSIS OF COAL GAS.

By Dr. LETHEBY.

Mr. President and Gentlemen,—At the meeting of this association at Birmingham in the month of May, 1865, when I had the honour of giving my second lecture on the "Chemistry of Gas Lighting," I directed your attention to the compound, or rather complex, nature of coal gas; and, after showing you experimentally the leading properties of each of its most important constituents, I described very briefly the means of discovering them. To-night, at your request, I have to resume the subject, and will enter, with more detail, into the processes which are used for the analysis of coal gas.

And, first, let me remind you what are the chief constituents of such gas, for these are the bodies to be sought for. In my former lecture, as some of you may perhaps remember, they were classified under the following heads:—

1. *The Combustible Non-Illuminating Constituents.*
2. *The Illuminating Hydrocarbons.*
3. *The Non-Essential Constituents, or Impurities.*

The first of these are *Hydrogen* (H) and *Carbonic Oxide* (C O), which, together, amount to from 30 to 60 per cent. of the gas, according to its quality.

The second are *Marsh Gas* or *Methyl-hydride* (CH_4), and perhaps other members of the series, as *Ethyl-hydride* (C_2H_6), *Propyl-hydride* (C_3H_8), *Butyl-hydride* (C_4H_{10}), and *Amyl-hydride* (C_5H_{12}); next, the Olefiant gas series, in which the volume of carbon is half that of hydrogen, as *Methylene* (CH_2), *Ethylene* (C_2H_4), *Propylene* (C_3H_6), *Butylene* (C_4H_8), and *Amylene* (C_5H_{10}); then comes the Benzole series, in which the proportion of carbon is still larger, as *Benzole* (C_6H_6), *Toluole* (C_7H_8), *Xylole* (C_8H_{10}), *Cumole* (C_9H_{12}), and *Cymole* ($C_{10}H_{14}$); and, lastly, others still richer in carbon, as *Acetylene* (C_2H_2), *Naphthalin* ($C_{10}H_8$), and *Anthracin* ($C_{15}H_{12}$).

The third group of constituents are *Carbonic Acid* (CO_2), *Oxygen* (O), *Nitrogen* (N), *Ammonia* (NH_3), *Bisulphide of Carbon* (CS_2), *Sulpho-hydrocarbons* (?), *Sulphuretted Hydrogen* (H_2S), and *Aqueous Vapour* (H_2O).

The composition, specific gravity, and combustion products of these constituents of coal gas are shown in the following table:—

TABLE No. 1.—*Composition, Specific Gravity, and Combustion Products of the Chief Constituents of Coal Gas.*

Name of Constituent.	Symbol or Formula.	Constituents per Volume.		Specific Gravity of the Gas or Vapour.	Weight of a Cubic Foot. (Grains.)	Vol. of Oxyg. required to Burn 1 Vol.	Prodcts. of Combustn.	
		C (Vol.)	H (Vol.)				CO_2 (Vol)	H_2O (Vol)
Atmospheric air	...	..	..	1·000	536·28	..	..	..
Hydrogen	H	..	..	0·069	37·00	0·5	..	1·0
Nitrogen	N	..	..	0·971	520·73	..	..	..
Oxygen	O	..	..	1·106	593·13	..	..	..
Ammonia	NH_3	..	1·5	0·590	317·41	0·75	..	1·5
Aqueous vapour	H_2O	..	..	0·622	333·57	..	..	..
Carbonic oxide	CO	0·5	..	0·967	518·58	0·5	1·0	..
Carbonic acid.....	CO_2	..	..	1·520	815·15	..	..	..
Cyanogen	CN	1·0	..	1·801	965·84	2·0	2·0	..
Sulphuretted hydrogn	H_2S	..	1·0	1·175	630·13	1·5	..	1·0
Bisulphide carbon ...	CS_2	0·5	..	2·645	1418·46	3·0	1·0	..
Marsh Gas Series—								
Methyl-hydride....	CH_4	0·5	2·0	0·553	296·66	2·0	1·0	2·0
Ethyl-hydride.....	C_2H_6	1·0	3·0	1·037	556·12	3·5	2·0	3·0
Propyl-hydride....	C_3H_8	1·5	4·0	1·522	816·22	5·0	3·0	4·0
Butyl-hydride.....	C_4H_{10}	2·0	5·0	2·005	1075·24	6 5	4·0	5·0
Amyl-hydride	C_5H_{12}	2·5	6·0	2·489	1334·80	8·0	5·0	6·0
Olefiant Gas Series—								
Methylene.....	CH_2	0·5	1·0	0·484	259·56	1·5	1·0	1·0
Ethylene.....	C_2H_4	1·0	2·0	0·968	519·12	3·0	2·0	2·0
Propylene.....	C_3H_6	1·5	3·0	1·452	778·68	4·5	3·0	3 0
Butylene.....	C_4H_8	2·0	4·0	1·936	1038·24	6·0	4·0	4·0
Amylene	C_5H_{10}	2·5	5·0	2·419	1297·26	7·5	5·0	5·0
Benzole Series—								
Benzole.....	C_6H_6	3·0	3·0	2·695	1445·27	7·5	6·0	3·0
Toluole	C_7H_8	3·5	4·0	3·179	1704·83	9·0	7·0	4·0
Xylole	C_8H_{10}	4·0	5·0	3·663	1964·39	10·5	8·0	5·0
Cumole	C_9H_{12}	4·5	6·0	4·147	2223·95	12·0	9·0	6·0
Cymole	$C_{10}H_{14}$	5·0	7·0	4·632	2484·05	13·5	10·0	7·0
Acetylene	C_2H_2	1·0	1·0	0·898	481·57	2·5	2·0	1·0
Naphthalin.....	$C_{10}H_8$	5·0	4·0	4·423	2371·97	12·0	10·0	4·0
Anthracin.....	$C_{15}H_{12}$	7·5	6·0	6·635	3558·22	18·0	15·0	6·0

It will be seen from this that the specific gravity of coal gas is entirely dependent upon the proportions of its leading constituents; that, in fact, as the gas becomes richer and richer in hydrocarbons, and therefore of higher illuminating power, its density or specific gravity increases. When, for example, it is chiefly composed of hydrogen and marsh gas, or methyl-hydride, as is the case with gas of low illuminating power, its density must necessarily be low, for the specific gravity of hydrogen is only 69 (atmospheric air being 1000), and of marsh gas, 553; whereas the denser hydrocarbons range from a gravity of 968 to 6635. The specific gravity of coal gas is, therefore, an indication of its composition, and is, indeed, the first step of its analysis. Let me, then, show you how this is determined, and what are the precautions necessary to ensure accurate results.

Specific Gravity of Gas.

This really means the relative weight of any volume of gas to the weight of the same volume of dry atmospheric air, at the same temperature and pressure as the gas. If, therefore, I take this glass globe, which is full of dry air, and counterpoise it accurately in the balance, I obtain, as you see, the exact weight of the globe and its contents (the dry air). I now exhaust it by means of the air-pump, and on returning it to the balance I find it has lost 34 grains in weight, which is manifestly the weight of the volume of atmospheric air which I have removed. Let me, in the next place, attach the exhausted globe to a stop-cock which is delivering coal gas; and having admitted the gas into the vacuum of the globe, I obtain a volume of gas which is equal to that of the air removed. Supposing that, after proper precautions, the temperature and pressure of the gas in the globe are exactly the same as they were in the case of the dry atmospheric air before its removal, it is evident that the weight of the gas, compared

with that of the dry air, will be the exponent of its specific gravity, for these are the relative weights of equal volumes of gas and air under the same conditions of temperature and pressure. I, therefore, return the globe to the balance, and find that the gas which has been admitted weighs 17·8 grains; and thus I ascertain that the relative weights of equal volumes of gas and dry atmospheric air—supposing them to be under the same conditions of temperature and pressure—are 17·8 and 34. These are also the relative proportions of their specific gravities; for, as 34 (the weight of the dry air) is to the specific gravity of atmospheric air (1000), so is 17·8 (the weight of the gas) to the specific gravity of the gas (523).

But, to obviate the necessity of exhausting the globe at each operation, I generally use this double-necked globe, which is kept constantly attached to a gas-pillar; and as the gas is always passing through it, it is always ready for weighing, there being a thermometer in the outlet-tube from the globe which shows the temperature of the gas Once for all the balance of the empty globe and the weight of the globe full of dry air, at a temperature of 60° Fahr. and a pressure of 30 inches of the barometer, have been determined, and thus I am in a condition to ascertain the specific gravity of the gas at any moment.

A rude but handy method of ascertaining approximatively the specific gravity of coal gas was devised by the late Mr. Alexander Wright, of Westminster. It consists of a light balloon, capable of holding a cubic foot of gas, and of a series of weights representing in units the 1000th part of the weight of a cubic foot of dry atmospheric air. The first step of the experiment is to expel the air from the balloon, by folding it up in the form in which it is kept packed in the box, and then ascertaining its weight in a delicate balance with the weights supplied. It is then filled with gas, and, being lighter than atmospheric air, it has a tendency to rise. Weights are then put into the little car of the balloon until it is exactly balanced in the air, and will neither rise nor fall. These weights, together with the weight of the balloon and car, represent the weight of the same volume (a cubic foot) of atmospheric air; and, supposing that the temperature of the gas was the same as that of the air, the difference between these weights and 1000 (the weight of the air) represents the specific gravity of the gas; for say it required 477 of the weights (including the weight of the balloon and car and the weights put into the car) to balance 1000 of air, it follows that the cubic foot of gas in the balloon must have weighed 523, for these are the weights necessary to make up the 1000, and therefore the relative weights of equal volumes of air and gas under the same conditions of temperature and pressure must have been 1000 and 523, which are their relative specific gravities.

In practice, however, it is rarely found that the temperature and pressure of the gas at the time of the experiment correspond with the standard temperature of 60° Fahr. and the standard pressure of 30 inches of the barometer, at which the weight, and consequently the specific gravity, of atmospheric air is estimated. It is necessary, therefore, to resort to calculation for the purpose of reducing the experimental weight of the gas at the observed temperature and pressure to what it would be at the standard temperature and pressure. Fortunately this is not a difficult process, for, as regards pressure, it is known that the weight of a given bulk of gas is always directly proportional to the pressure; for the greater the pressure upon the gas, the more of it will be forced into a given bulk. If, therefore, a globe full of gas weighs 17·2 grains at a pressure of 29·2 inches of the barometer, it will hold 17·69 grains of the gas at a pressure of 30 inches of the barometer; for—

$$\text{As } 29{\cdot}2 : 17{\cdot}2 :: 30 : 17{\cdot}69.$$

And thus we correct for *weight and pressure*. On the other hand, if it be required to correct *the volume* of the gas *for pressure*, the rule must obviously be an inverse one, because the bulk of any gas is always inversely as the pressure—the greater the pressure the less the bulk; 100 volumes of gas, therefore, at 29·2 inches of the barometer, will be only 97·33 volumes at 30 inches of the barometer, for—

$$\text{As } 30 : 100 :: 29{\cdot}2 : 97{\cdot}33.$$

In this way we correct for bulk and pressure.

Again, corrections for temperature are founded on the fact that every gas expands the 1-491·13th part of its bulk at 32° Fahr. for every degree of heat above

that temperature. This is the result of the careful investigation of M. Regnault, whose number, representing the rate of expansion of gases, is nearer the truth than that of Gay Lussac and Dalton (the 1-480th part), or of Rudberg (the 1-493rd part). For all practical purposes, however, it is sufficiently near to the truth if we regard the rate of expansion as the 1-491st part of the bulk of the gas at 32° for every degree of Fahrenheit above that temperature. Suppose, therefore, that at the time of making the experiment the globe full of gas weighed 17·2 grains, when the pressure of the barometer was only 29·2 inches, and the temperature of the gas was 66·4° of Fahrenheit, the problems to be solved are—

1. What would have been the *weight* of the globe full of gas at the standard pressure of 30 inches of the barometer, and the standard temperature of 60° Fahr.? and
2. What would have been the *bulk* of the gas at that pressure and temperature?

The mode of proceeding, in each case, is as follows:—First, correct the weight and bulk of the gas for pressure; and thus we find, as in the illustrations already given, that at 30 the weight of the globe full of gas would have been 17·69 grains, and its bulk 2·67 per cent. less than at 29·2 of the barometer (100 volumes becoming 97·33 volumes). Then correct for temperature, using, for this purpose, the figures last obtained; and, as the rate of expansion only applies to the bulk of the gas at 32°, it is necessary to use a process whereby the volumes at each temperature may be reduced to a common denomination. This is accomplished by assuming that 491 volumes of the gas, at 32° Fahr., were the subjects of experiment in each case, and that the rate of expansion was the $\frac{1}{491}$ part of the volume at 32° for every degree of Fahrenheit above it. It follows, therefore, that 491 volumes of gas at 32° would become 525·4 volumes at 66·4°, which is the observed or experimental temperature (for 66·4 − 32 + 491 = 525·4), and 519 volumes at 60°, which is the required or standard temperature (for 60 − 32 + 491 = 519). Now, as the bulk of the gas is directly as the temperature (according to this rate), it follows that 97·33 volumes of gas at 66·4° would become 96·14 volumes at 60°; for—

66·4			60·0		
32·0			32·0		
34·4			28·0		
491 0			491·0		
As 525·4	:	97·33	:: 519·0	:	96·14

But, in correcting the weight of a given volume of gas for temperature, the process is reversed, because, as the temperature rises, the volume increases; and hence a given bulk of the gas weighs less. If, therefore, the globe of gas at 66·4° Fahr., and at 30 inches of the barometer, weighed 17·69 grains, it is manifest that the same volume of gas at 60° would weigh 17·91 grains; for—

As 519 : 17·69 :: 525·4 : 17·91

The weight, therefore, of the gas, at a pressure of 29·2 inches of the barometer, and at a temperature of 66·4° Fahr., which were the experimental numbers, would be increased from 17·2 grains to 17·91, by correcting it to the standard pressure (30 bar.) and temperature (60° Fahr.).

To facilitate these corrections, by obviating the difficulties of calculations, a table has been constructed, of which this is a copy, giving the volumes at different temperatures and pressures of 1000 parts of gas at the standard temperature and pressure. This table is most useful, when it is required, in photometrical observations, to correct the volume of gas as it traverses the meter in a warm room, for it shows at a glance the standard volume of the warm gas:—

TABLE No. 2.

Correction of the Volume of Gas at different Temperatures, and under different Atmospheric Pressures.

Bar.	Ther. 40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°	62°	64°	66°	68°	70°	72°	74°	76°	78°	80°	82°
28·0	·971	·967	·963	·960	·956	·952	·948	·944	·941	·937	·933	·930	·926	·922	·919	·915	·911	·907	·904	·900	·897	·893
28·1	·974	·970	·967	·963	·959	·955	·952	·948	·945	·941	·937	·933	·929	·926	·922	·919	·914	·911	·907	·904	·900	·896
28·2	·978	·973	·970	·968	·963	·959	·955	·951	·947	·944	·940	·936	·933	·929	·925	·922	·917	·914	·911	·907	·903	·899
28·3	·982	·977	·974	·970	·966	·963	·958	·955	·951	·947	·943	·940	·936	·932	·929	·925	·921	·917	·914	·911	·906	·902
28·4	·985	·980	·978	·973	·970	·966	·962	·958	·954	·951	·947	·943	·939	·936	·932	·928	·924	·920	·917	·914	·910	·905
28·5	·988	·984	·980	·978	·973	·970	·965	·961	·958	·954	·950	·946	·943	·939	·935	·932	·927	·923	·920	·917	·913	·909
28·6	·992	·987	·984	·980	·976	·973	·969	·965	·961	·957	·953	·950	·946	·942	·939	·935	·931	·927	·923	·919	·916	·912
28·7	·995	·991	·987	·983	·980	·976	·972	·968	·964	·961	·957	·953	·949	·945	·942	·938	·934	·930	·926	·922	919	·915
28·8	·998	·995	·991	·987	·983	·980	·976	·971	·968	·964	·960	·956	·952	·949	·945	·941	·937	·934	·929	·925	·922	·918
28·9	1·002	·998	·994	·991	·987	·983	·979	·975	·971	·968	·963	·960	·956	·952	·948	·944	·940	·937	·933	·928	·925	·921
29·0	1·006	1·001	·998	·994	·990	·986	·982	·978	·974	·971	·967	·963	·959	·955	·952	·948	·943	·940	·936	·932	·928	·925
29·1	1·009	1·004	1·001	·998	·993	·989	·985	·982	·978	·974	·970	·966	·962	·959	·955	·951	·947	·943	·939	·935	·932	·928
29·2	1·012	1·008	1·004	1·001	·997	·993	·989	·985	·981	·977	·973	·969	·966	·962	·958	·954	·950	·947	·942	·938	·935	·932
29·3	1·016	1·011	1·007	1·004	1·000	·996	·992	·988	·984	·981	·977	·973	·969	·965	·961	·957	·953	·950	·946	·941	·938	·935
29·4	1·019	1·015	1·011	1·008	1·004	1·000	·996	·992	·988	·984	·980	·976	·972	·969	·965	·961	·956	·953	·949	·945	·941	·938
29·5	1·023	1·018	1·014	1·011	1·007	1·004	1,000	·995	·991	·987	·983	·979	·975	·971	·968	·964	·960	·956	·952	·948	·945	·941
29·6	1·026	1·022	1·018	1·015	1·010	1·006	1·002	·998	·994	·991	·987	·982	·979	·975	·971	·967	·963	·959	·955	·952	·948	·945
29·7	1·030	1·025	1·021	1·018	1·014	1·010	1·006	1·002	·997	·994	·990	·986	·982	·978	·974	·970	·966	·962	·959	·955	·951	·948
29·8	1·033	1·029	1·025	1·022	1·017	1·013	1·009	1·005	1·001	·997	·993	·989	·985	·981	·977	·974	·970	·966	·962	·958	·954	·951
29·9	1·037	1·032	1·028	1·025	1·021	1·017	1·013	1·009	1·004	1·001	·997	·992	·989	·985	·981	·977	·973	·969	·965	·961	·957	·954
30·0	1·040	1·036	1·032	1·028	1·024	1·020	1·016	1·012	1·008	1·004	1·000	·996	·992	·988	·984	·980	·976	·972	·968	·964	·961	·957
30·1	1·043	1·039	1·035	1·032	1·028	1·023	1·019	1·015	1·011	1·007	1·004	·999	·995	·991	·987	·983	·979	·975	·972	·968	·964	·960
30·2	1·047	1·043	1·039	1·035	1·031	1·027	1·023	1·019	1·015	1·011	1·007	1·003	·998	·994	·990	·987	·983	·979	·975	·971	·967	·963
30·3	1·051	1·047	1·043	1·039	1·034	1·030	1·026	1·022	1·018	1·014	1·010	1·006	1·002	·998	·994	·990	·986	·982	·978	·974	·970	·966
30·4	1·054	1·050	1·046	1·042	1·038	1·034	1·029	1·026	1·021	1·017	1·013	1·009	1·005	1·001	·997	·993	·989	·985	·981	·977	·974	·969
30·5	1·058	1·053	1·050	1·045	1·041	1·037	1·033	1·029	1·025	1·021	1·017	1·012	1·008	1·004	1·000	·997	·993	·989	984	·980	·977	·973
30·6	1·061	1·056	1·053	1·049	1·045	1·040	1·036	1·032	1·028	1·024	1·020	1·016	1·012	1·008	1·004	1·000	·996	·992	·988	·984	·980	·976
30·7	1·064	1·060	1·056	1·052	1·048	1·044	1·040	1·036	1·031	1·027	1·023	1·019	1·015	1·011	1·007	1·003	·999	·995	·991	·987	·983	·979
30·8	1·068	1·063	1·060	1·056	1·051	1·047	1·043	1·039	1·035	1·031	1·027	1·022	1·018	1·014	1·010	1·006	1·002	·999	·994	·990	·986	·982
30·9	1·072	1·067	1·063	1·059	1·055	1·051	1·046	1·043	1·038	1·034	1·030	1·026	1·022	1·017	1·014	1·010	1·006	1·002	·997	·993	·990	·985
31·0	1·075	1·070	1·067	1·063	1·058	1·054	1·051	1·046	1·042	1·037	1·033	1·029	1·025	1·021	1·017	1·013	1·009	1·005	1·000	·996	·993	·989

The Calculations from which this Table has been drawn up are based on the experiments of Dulong, Regnault, and Magnus.

Other corrections are necessary when it is required to know the proportion of moisture in gas standing over water, as is the case in an ordinary gasholder; for, under these circumstances, the quantity of aqueous vapour is influenced by the temperature and pressure of the gas. These corrections are founded on the results of careful observations as to the volume and weight of aqueous vapour in gas saturated with moisture at all common temperatures, and the general conclusions may be thus expressed:—

1. The volume of gas is increased by the presence of aqueous vapour.
2. Its weight is also affected by it, according as the specific gravity of the gas is greater or less than that of aqueous vapour; and
3. Its elastic force or pressure is likewise influenced by the weight of the aqueous vapours.

These facts are represented in the following table:—

TABLE No. 3.—*Amounts of Aqueous Vapour, by Weight and Volume, in a Cubic Foot of Gas over Water, as in a common Gasholder, and the Elastic Force of it, in Inches of Mercury, at different Temperatures.*

Temp.	Weight of the Aq. Vap.	Expansion from Aq. Vap.	Elastic Force of Aq. Vap.	Temp.	Weight of Aq. Vap.	Expansion from Aq. Vap.	Elastic Force of Aq. Vap.
Deg. F.	Grs.	Per Cent,	In.	Deg. F.	Grs.	Per Cent.	In.
22	1·4	0·39	0·118	71	8·3	2·60	0·759
24	1·5	0·43	0·129	72	8·5	2·69	0·785
26	1·7	0·47	0·141	73	8 8	2·79	0·812
28	1·8	0·51	0·153	74	9·1	2·88	0 840
30	2·0	0·56	0·167	75	9·4	2·98	0·868
32	2·1	0·60	0·181	76	9·7	3·08	0·897
34	2·3	0·65	0·196	77	10·0	3·19	0·927
36	2·5	0·71	0·212	78	10·3	3·30	0 958
38	2·7	0·77	0·229	79	10·6	3·41	0·990
40	2·9	0·83	0·247	80	11·0	3·52	1·023
42	3·1	0·89	0·267	81	11·3	3·65	1·057
44	3·3	0·96	0·288	82	11·7	3·78	1·092
46	3·6	1·05	0·311	83	12·0	3·91	1·128
48	3·8	1·13	0·335	84	12·4	4·05	1·165
50	4·1	1·21	0·361	85	12·8	4·19	1·203
52	4·4	1·31	0·388	86	13·2	4·32	1·242
54	4·7	1·41	0·418	87	13·6	4·46	1·282
56	5·0	1·52	0·449	88	14·0	4·61	1·323
58	5·4	1·64	0·482	89	14·4	4·77	1·366
60	5·8	1·76	0·518	90	14·8	4·93	1·410
61	6·0	1·82	0·537	91	15·3	5·10	1 455
62	6·2	1·88	0·556	92	15·7	5·26	1·501
63	6·4	1·96	0·576	93	16·2	5·44	1·548
64	6·6	2·03	0 596	94	16·7	5·62	1·596
65	6 8	2·10	0·617	95	17·2	5·81	1·646
66	7·0	2·18	0·639	96	17·7	6·00	1·697
67	7·3	2·25	0·661	97	18·2	6·20	1·751
68	7·5	2·33	0·684	98	18·7	6·41	1·806
69	7·8	2·42	0·708	99	19·3	6·61	1·862
70	8·0	2·50	0·733	100	19·8	6·83	1·918

Let us suppose, then, that we have 100 cubic inches of gas over water, and therefore saturated with moisture, at a temperature of 65° Fahr., and that it weighed 18 grains—a cubic foot of it (1728 cubic inches) would weigh 311 grains; and, by referring to the table, we find that 6 8 grains are attributable to the moisture in it; so that the weight of the dry gas is 304·2 grains; and therefore, 100 cubic inches of the moist gas, weighing 18 grains, would contain 17·6 grains of dry gas. Now as the volume of the gas has been increased by the moisture, at the rate of 2·1 per cent., the volume of the dry gas must have been 97·94 cubic inches; and thus we obtain the weight and bulk of the dry gas in 100 cubic inches of gas saturated with moisture.

Another method of correcting for moisture is by means of the data furnished by the elastic force of aqueous vapour at different temperatures; for as the barometric pressure of the moist gas at the time of the experiment is made up

of the combined pressure or weight of the dry gas and the aqueous vapour, it is manifest that the relative bulks of the two must be in the same proportion; and hence it follows that the total pressure of the dry gas and aqueous vapour must be to the partial pressure, or elastic force of the aqueous vapour, as the total bulk of the two is to the partial bulk of the aqueous vapour. Suppose, therefore, by way of illustration, that we have been experimenting with 100 cubic inches of gas saturated with moisture at a temperature of 65° Fahr., and a pressure of 29·2 of the barometer. On reference to the table, we find that the elastic force of aqueous vapour at that temperature is 0·617 of an inch of mercury; and as 29·2 (the total pressure) is to 0·617 (the pressure of the aqueous vapour), so is 100 (the total bulk of the gas and aqueous vapour) to 2·11 (the bulk of the aqueous vapour). And when this is corrected for pressure and temperature, so as to bring it from 29·2 bar. and 65° Fahr. to 30 bar. and 60° Fahr., we are able to determine the standard bulk of the aqueous vapour in the gas; and this enables us to determine its weight, for a cubic inch of aqueous vapour, at 30 inches of the barometer and at 60° Fahr., weighs 0·1929 of a grain.

But the simplest and readiest method of overcoming the difficulties occasioned by the presence of moisture in the gas is to dry it, as I am here doing, by passing it through a glass tube, about 18 inches long, and half an inch internal diameter, filled with fragments of fused chloride of calcium. By this means the gas is deprived of its moisture, and it enters the glass globe in such a condition as to require no other corrections than those for pressure and temperature.

And now let me show you experimentally another and much easier method of determining the specific gravity of coal gas. It is founded upon a physical law which has been long established for liquids of different densities, and which the late Professor Graham demonstrated in the cases of gases—namely, that the rates of effusion, or passage of different gases into a vacuum, through a minute aperture in a *very thin plate or disc of metal*, are inversely as the square roots of the densities or specific gravities of the different gases. This will be evident from the table before you.

TABLE No. 4.—*Specific Gravity, Square Root of Density, and Effusion Time and Effusion Rate of different Gases (Graham).*

Name of Gas.	Specific Gravity.	Square Root of Sp. Gr or Effusion Time of given Volume.	1 ÷ Square Root of Sp. Gr. or Effusion Rate in given Time.
Hydrogen	0·0693	.... 0·2632	.... 3·7994
Light carburetted hydrogen	0·5549	.... 0·7449	.... 1·3424
Olefiant gas	0·9712	.... 0 9855	.... 1·0147
Carbonic oxide . . .	0·9712	.... 0·9855	.... 1·0147
Nitrogen	0·9714	.... 0 9856	.... 1·0147
Atmospheric air . . .	1·0000	.... 1·0000	.... 1·0000
Oxygen	1·1056	.... 1·0515	.... 0·9510
Sulphuretted hydrogen .	1·1793	.... 1 0860	.... 0·9208
Carbonic acid	1·5290	.... 1·2365	.... 0·8087

So that the time of passage into a vacuum of equal volume of different gases varies as the square root of their densities, and therefore the velocities of passage will be in an inverse proportion, or as 1 divided by the square root of the density of the gas. Now if, instead of allowing the gas to stream through a fine hole in a very thin plate of metal into a vacuum, as I have just shown you, it be forced out by means of a constant pressure of a given height or column of water or mercury, the result will be the same, and it will afford the means of determining the specific gravity of a gas. When small quantities of gas are to be operated on, the instrument must be proportionally delicate, and the best form of it is that described and figured by Bunsen, in his work on "Gasometry." It consists of a small glass tube, which is open at the bottom, and furnished at the top with a well-ground glass stop-cock, having a tube into which there is fixed a thin disc of platinum foil, with an extremely small aperture; and in order that the gases under examination shall issue from the aperture under precisely the same conditions of pressure, there are certain precautions to be observed in graduating the height of the mercurial column, and

in reading off the volume of the gas from its starting-point to the end. For our purpose, however, there is a simpler apparatus, designed by Schilling, and manufactured by Messrs. Wright and Co., of Westminster, who have kindly lent it to me for experiment. It is, as you see, a cylindrical glass vessel, capable of holding about 100 cubic inches of gas, having a stop-cock, which is guarded by a very thin disc of platinum, perforated with an extremely small hole. There is a tube for filling the vessel with gas, and a glass chamber for holding the necessary quantity of water. In using the vessel, you first ascertain the time required for the discharge of a given volume of atmospheric air, and then the time for the discharge of the same volume of coal gas. According to the preceding law, the square of the number of seconds required by the gas, divided by the square of the number of seconds required by the air, will give the specific gravity of the gas. But the experiment may be made with a meter, a governor, and a delicate pressure-gauge, as in Lowe's jet photometer, using a perforated disc instead of the steatite burner, which is really a tube, and therefore liable to error. In this way it is easy to determine the time required for the flow or passage of a given volume of gas, and this, conjoined with the height of the flame, would afford a far more reliable means of estimating the quality of gas than the durability test of Dr. Fyfe, or the jet photometer of Mr. Lowe. Some of you may remember that I described both of these methods of testing gas in the third lecture which I had the honour of giving to the association at their meeting in London in 1866, when I explained that the durability of a jet of gas, from an aperture of a given size, with a flame of a given height, as well as the pressure necessary to produce such a flame, were much relied on by the late Dr. Fyfe, of Glasgow, as a means of estimating the illuminating power of gas. The jet which he used had a diameter of the 1-33rd of an inch, and the flame was kept at a uniform height of 4 inches. In this manner he found that a given volume of gas of different qualities burnt out in different times, thus:—

TABLE No. 5.—*Durability of a Cubic Foot of Gas from*

Common Newcastle coal	50·5 minutes.
Wigan cannel	57·0 „
Lesmahago cannel	65 0 „
Wemyss cannel	75·0 „
Boghead cannel	81·0 „

And with respect to the pressure necessary to produce a flame 5 inches in height from a jet the 1-40th of an inch in diameter, he obtained the following results:—

TABLE No. 6.—*Pressure and Rate of Consumption of Gas of different Specific Gravities.*

Pressure. Inch.	Consumption per Hour. Cubic Feet.	Specific Gravity of the Gas.
0·6	0·67	0·841
0·8	0·77	0·729
1·0	0·86	0·552
1·2	0·94	0·595
1·4	1·02	0·551
1·6	1·09	0·515
1·8	1·15	0 486
2·0	1·21	0·461

His deductions from these results were that the specific gravity of gas, or, in other words, its quality as regards richness in condensable hydrocarbons, was inversely as the square roots of the pressures; and that the volume consumed in a given time was as the square roots of the pressures. He relied so much on this test that he thought it capable of taking the place of the ordinary photometer; and, no doubt, with proper precautions, using a perforated disc instead of a tubular jet, very accurate results might be obtained.

Chemical Analysis of Gas.

The constituents of coal gas (as shown in Table No. 1) are, as you perceive, very numerous, but it is hardly necessary, in the analysis of gas, to seek for more than the following—the proportions of which are in some cases exceedingly variable:—

TABLE No. 7.—*Chief Constituents of Coal Gas.*

Hydrogen	25 to 50	per cent.	by vol.
Light carburetted hydrogen, $C H_4$	35 „ 52	„	„
Condensible Hydrocarbons: Olefiant gas, C_2H_4; Propylene, C_3H_6; Butylene, C_4H_8	8 „ 20	„	„
Benzole and its series	? „ ?	„	„
Acetylene, C_2H_2	? „ ?	„	„
Naphthalin, $C_{10}H_8$	? „ ?	„	„
Carbonic oxide, CO	5 „ 9	„	„
Carbonic acid, CO_2	0 „ 2	„	„
Cyanogen, CN	? „ ?	per cent.	by vol.
Ammonia, NH_3	0·00 „ 0·06	„	„
Bisulphide of carbon, CS_2	0·004 „ 0·04	„	„
Aqueous vapour, H_2O	0·60 „ 2·50	„	„
Oxygen	0·00 „ 0·10	„	„
Nitrogen	0·00 „ 8·00	„	„

In the analyses which have been published of the average composition of the gas supplied to London, the chief constituents are as follows:—

TABLE No. 8.—*Average Composition of London Gas.*

	Common Gas (12-candle).	Cannel Gas (20-candle).
Hydrogen	46·0	27·7
Light carburetted hydrogen	39·5	50·0
Condensible hydrocarbons	3·8	13·0
Carbonic oxide	7·5	6·8
Carbonic acid	0·6	0·1
Aqueous vapour	2·0	2·0
Oxygen	0·1	0·0
Nitrogen	0 5	0·4
	100·0	100·0

The analysis of gas is generally effected by means of absorbent substances introduced into a measured volume of gas in a graduated glass tube, called an *eudiometer tube*, and to Professor Bunsen, of Heidelberg, is due the merit of giving accuracy to these investigations. The eudiometer tube which he employed was graduated independently of its volume, as you here see, and the values of the divisions were afterwards determined by very careful calibration. To avoid the difficulties occasioned by the wetting of the inside of the tube with the liquid reagents, he used them in a solid form, fastened to wires, by which means he was able to pass them up into the gas, and afterwards, when the required absorption was effected, to pull them out of it, leaving the interior of the tube clean and dry. A couple of platinum wires are fused into the top of the tube for the purpose of passing an electric spark, and so exploding mixtures of the gas with oxygen. This, with a delicate thermometer, a barometer, a mercurial trough, and a telescope for reading off the volume of the gas after each operation, constitute the apparatus of Bunsen; and, when used with proper care, it furnishes most accurate results. But the great drawback to the process is the time required for an analysis, the absorbents acting but slowly, and the gas requiring an uncertain time to return to its original temperature after the tube has been warmed by handling it; besides which it is necessary to have a room in such a situation and of such a structure as that its temperature shall remain unchanged during the performance of an experiment. These are difficulties of no ordinary character, and, therefore, attempts have been made to obviate them by using two sets of vessels—one for the absorption of the gas, which is called a laboratory tube, and another for its measurement, the eudiometer, which is surrounded with water, and thus kept at a uniform temperature and pressure during the experiment. The first improvements in this direction were made by MM. Regnault and Reiset, in their memorable investigations on the composition of gases, and their apparatus and processes of analysis are fully described in Regnault's "Elements of Chemistry." Later still, in 1854, the apparatus was still further improved and simplified by Dr. Frankland, who described it in Vol. VI. of the "Quarterly Journal of the Chemical

Society," saying that the conditions which he endeavoured to secure by it were the following:—

1. The determination of the gaseous volumes entirely independent of the pressure and temperature of the external atmosphere.

2. The self-correction of such determinations as regards the tension of aqueous vapour, and the variations in the density of mercury.

3. The expression of each change of volume in numerical differences as large as possible.

4, and lastly, to avoid the inconvenience and loss of time occasioned by tedious calculations, references to tables, &c., the numerical expression of each volume actually read off is either the true and corrected volume, or a number from which such volume can be at once obtained by the most simple arithmetical process.

The advantages of these qualifications or conditions are obvious, and I must refer you to his article on the subject for a detailed description of the apparatus. Other improvements of Regnault's instrument have been proposed by Dr. Williamson, Dr. Russell, and Mr. Ward; but they need not detain us further than by saying that they aim at still greater simplicity in the absorption and in the measurement of the gas. I apprehend, however, that few of you will resort to these complicated processes of investigation, and that I shall best consult the object of our meeting, if I describe to you the simplest means by which we can obtain a knowledge, even if it be but approximatively correct, of the composition of coal gas.

1. The *amount of moisture* in gas is always determined by means of fused chloride of calcium; and it may be used in the form of a pellet or ball let up into a measured quantity of gas over mercury, when the loss of volume from absorption indicates the amount of moisture present, care being taken to secure the proper conditions of temperature and pressure; or it may be estimated by slowly passing a known volume of gas through a previously weighed glass tube filled with fragments of chloride of calcium; and the increase of weight represents the amount of moisture present. This amount, in grains, may be converted into cubic inches by remembering that each cubic inch of aqueous vapour at a temperature of 60° Fahr., and a pressure of 30 inches of the barometer, weighs 0·1929 of a grain.

2. *Carbonic Acid* is qualitatively determined by merely passing the gas through a little lime or baryta water, which it renders milky. The actual amount of it may be ascertained by introducing a pellet of fused potash into the gas, which has been previously dried, as in the last experiment, by means of fused chloride of calcium, and the reduction of volume is then due to the absorption of carbonic acid; or it may be estimated by attaching a glass tube containing fragments of caustic potash to the chloride of calcium tube already described, and the increase in weight is due to carbonic acid. In this experiment care must be taken to remove all moisture from the gas by means of the chloride of calcium tube before it reaches the potash, because potash, like chloride of calcium, will absorb moisture, and thereby increase in weight. Every cubic inch of carbonic acid, at ordinary temperature and pressure, weighs 0·4717 of a grain.

3. *Oxygen.*—This is easily determined by means of an alkaline solution of pyrogallic acid—an acid which is largely prepared and used for photography. A measured volume of gas is let up into an ordinary Cooper's eudiometer tube, previously filled with water, as I am now doing, and after allowing the tube to stand in the vessel of water for a few minutes, so as to equalize its temperature, the volume of gas is read off. A piece of caustic potash, about an inch long, is then let up into the tube, and allowed to dissolve in the water—the tube being kept in motion with the thumb firmly over the opening, so as to dissolve the potash without allowing any of the gas to escape. When the potash is dissolved, the tube is returned to the vessel of water for the purpose of equalizing its temperature, and after a few minutes the volume of gas is read off; the loss, if any, is due to carbonic acid. A little pyrogallic acid, about half a thimbleful, in the condition of dry powder, is next to be put into the potash solution in the tube, and having placed the thumb over the orifice of the tube as before, it is to be well shaken, so as to bring all the gas into contact with the alkaline solution of pyrogallic acid. If oxygen be present, the solution will acquire a brown colour, and after returning it to the equalizing vessel of water, the amount of absorption can be read off, and this is due to

oxygen. Once for all, I may say that when using these tubes for the analysis of gas, the greatest care must be taken to prevent the escape of gas, or the access of air, and the temperature of the gas must always be equalized by sinking the tube in the vessel of water, before the volume of gas is read off. With a little practice, all these conditions may be easily secured. If the determination of oxygen is effected in the eudiometer tube of Bunsen, or the laboratory tube of Frankland, over mercury, the absorption is effected by means of a ball of papier-maché soaked in a strong solution of pyrogallic acid in potash—the carbonic acid having been previously removed from the gas.

4. *Carbonic Oxide.*—This is removed from coal gas by means of a concentrated solution of sub-chloride of copper, formed by shaking a strong solution of chloride of copper in muriatic acid, with a quantity of copper filings, and keeping the copper filings always in the bottle with the solution. If care be taken to remove as much water as possible from the bend of the copper tube containing the gas, and to supply its place with the concentrated solution of sub-chloride of copper, the analysis may be made in the ordinary way, but if much water be present, the sub-chloride will be precipitated and rendered almost inert. It is better, therefore, to make the examination of the gas over mercury, letting up a ball of papier-maché, saturated with the acid solution of sub-chloride. After the absorption of the carbonic oxide, a little potash should be used to absorb the fumes of muriatic acid which may remain. It is hardly necessary to say that the experiment must be made with gas from which both oxygen and carbonic acid have been previously removed, because the former of these will be absorbed by sub-chloride of copper, and the latter by potash—thus giving erroneous results, if they are present.

5. *Condensible Hydrocarbons.*—These are freely absorbed by chlorine, bromine, and fuming sulphuric acid. If chlorine be used, as was the practice of Dr. Fyfe, the tube must be kept in the dark, or it will combine with hydrogen and light carburetted hydrogen, and so give false results. Bromine, however, has the property of combining with the hydrocarbons, without touching the other constituents of coal gas, and if it were not that it forms ethereal compounds, which diffuse vapour through the gas, and so affect its volume, the results would be very trustworthy. As it is, indeed, they are sufficiently reliable for common purposes. I take, as you now see, a known volume of coal gas in an ordinary Cooper's tube, and having equalized its temperature and read its volume, I drop into the water at the bend of the tube a single drop of bromine, and then on closing the tube with my thumb, I agitate the gas and bromine water with just enough violence to diffuse the vapour of bromine throughout the tube. After standing for five or six minutes, and observing that there is still enough bromine to colour the gas, I add a small piece of caustic potash, and again close the tube and agitate it. As you perceive, when I open the tube under water, there has been considerable absorption and condensation. I now return the tube to the equalizing vessel, and when the temperature is restored, I read off the absorption, which is due to carbonic acid and condensable hydrocarbons. As the amount of the first has already been determined, the volume of hydrocarbons is easily obtained.

But, as I have stated, there is a slight source of error in this method of determining the amount of condensible hydrocarbons, because of the presence of an uncertain quantity of the ethereal vapour of the bromine compounds; and hence, in accurate investigations, it is best to absorb the hydrocarbons by means of a ball of wood charcoal or coke impregnated with fuming sulphuric acid. This, of course, must be done in a tube over mercury—a pellet of potash, or a piece of cotton wool, saturated with a solution of potash, being afterwards used to absorb the residual acid fumes; but even this method is not sufficient to discover the exact nature of the hydrocarbons, for you will perceive, by reference to the diagram (Table No. 1), that the hydrocarbons, which are condensible by fuming sulphuric acid, contain very different proportions of carbon, and are, therefore, of different values as illuminating agents. Mr. Lewis Thompson has proposed to solve this question by ascertaining the specific gravity of the gas before and after its condensation with bromine, and thus to deduce the specific gravity of the vapour of the hydrocarbons. Let us take an example from a specimen of Boghead cannel gas. Suppose the gravity of the gas before condensation with bromine was 0·752, and after such condensation it was 0·555; and suppose also that the amount of condensation with bromine was 30 per cent. by volume, it follows that if the weight of the

residual 70 volumes ($70 \times 0{\cdot}555 = 38{\cdot}85$) be subtracted from the weight of the original gas ($100 \times 0{\cdot}752 = 75{\cdot}20$), the residue ($75{\cdot}20 - 38{\cdot}85 = 36{\cdot}35$) must be the weight of the 30 volumes condensed by bromine; and, therefore, $36{\cdot}35 \div 30 = 1{\cdot}212$, which is the specific gravity of the hydrocarbon vapours in question. The effusion tube of Bunsen, already described, is particularly well suited for the quick determination of the specific gravity of the gas before and after its treatment with bromine. A still better and more exact method of estimating the proportion of carbon in the condensed vapours is to mix the gas with oxygen, and, after exploding it, to ascertain the amount of carbonic acid produced. If this be done with the original gas, and then with the gas from which the hydrocarbon vapours have been removed by means of fuming sulphuric acid, the difference in the proportions of carbon will furnish the necessary data for estimating the composition of the condensed vapours. This will be evident from what follows:—

6. *Estimation of Marsh Gas (light Carburetted Hydrogen), Hydrogen, Carbonic Oxide, and Nitrogen.*—As there are no absorbents for hydrogen and light carburetted hydrogen, it is necessary to determine their proportions in coal gas by exploding them with oxygen, and so converting them into water and carbonic acid, from which the amounts of hydrogen and carbon may be easily ascertained. The method of proceeding is, first, to remove the condensible hydrocarbons and carbonic acid from coal gas by means of fuming sulphuric acid, and a ball of cotton saturated with a solution of caustic potash, as I have just described. In this way we obtain a mixture of hydrogen, light carburetted hydrogen, carbonic oxide, and nitrogen. About one cubic inch of this mixture is transferred to an exploding eudiometer tube, moistened on the inside with a little water, and the exact volume of it is read off. It is then treated with about four times its volume of pure oxygen gas, and again the volume is read off. After this the mixture is exploded by passing an electric spark across the platinum wire of the tube—taking care to press so firmly upon the open end of the tube as to guard against loss of gas from the force of the explosion. In the straight tube of Bunsen this is done by pressing the tube firmly upon a piece of india-rubber placed at the bottom of the mercurial trough; and in the case of the bent eudiometer tube of Ure, which I am now using, it is effected by holding the thumb forcibly upon the open end of the tube. After the explosion the volume of the gas is again read off. And now we proceed to estimate the quantity of carbonic acid produced by means of a ball of cotton saturated with a solution of caustic potash. The loss of volume, after such treatment, is obviously due to the absorption of carbonic acid; and the residual gas must be a mixture of the nitrogen contained in the original gas, and of the oxygen which has been used in excess. Having, therefore, noted its exact quantity, we add about four times its volume of pure hydrogen, and again note its volume. The electric spark is once more passed across the platinum wire, and thus the oxygen is made to combine with the hydrogen, and to form water. For the last time the volume is again noted, and, as two volumes of hydrogen unite with one volume of oxygen to form water, the loss of volume, divided by three, gives the proportion of oxygen present, and this, subtracted from the volume of the gas, before the hydrogen was added to it, gives the proportion of nitrogen present! In all these experiments the greatest care must be taken to guard against errors from alterations of temperature and pressure.

And now comes the question—How are we to determine from these results the proportions of hydrogen, light carburetted hydrogen, carbonic oxide, and nitrogen, which were the constituents of the gas? If you look at the diagram (Table No. 1) you will observe that hydrogen combines with half its volume of oxygen to form water, which occupies no gaseous volume in the eudiometer tube; and that light carburetted hydrogen (there called methyl-hydride) consumes twice its volume of oxygen to form water, which has no gaseous bulk, and its own volume of carbonic acid gas; while carbonic oxide takes half its volume of oxygen and produces its own volume of carbonic acid. It is evident, from this, that the water produced occupies no gaseous bulk, and the volume of carbonic acid produced represents the combined volumes of light carburetted hydrogen and carbonic oxide, while the volume of oxygen has its determinate relations to each of them, consequently the respective proportions of the constituent gases may be found from three simple equations; for if the volume of the original gas (*minus* the nitrogen) be called G, and that of the oxygen consumed, O; and that of the carbonic acid produced, C; it is manifest that

$G = H + C H_4 + CO$ — the three constituent gases.
$O = 0{\cdot}5 + 2 + 0{\cdot}5$ — the oxygen required by each.
$C = 0 + 1 + 1$ — the carbonic acid produced.

And suppose that, in an experiment, it has been ascertained that G is equal to 11 volumes, O to 11·5 volumes, and C to 5, then, as the volume of carbonic acid produced represents the combined volumes of the light carburetted hydrogen and carbonic oxide of the gas, it follows that

$G - C$, or $11 - 5 = 6$, is the volume of the hydrogen present.

And $\frac{2O - G}{3}$ or $\frac{23 - 11}{3} = 4$, is the volume of light carburetted hydrogen present

And the last deducted from the total volume of carbonic acid produced, or $5 - 4 = 1$, must be the volume of carbonic oxide present.

If it be required to determine the amount of carbon in the condensible hydrocarbons, it is necessary to explode a given volume of the original gas, before the hydrocarbons have been absorbed, by mixing it with about five times its volume of pure oxygen, and then ascertaining the proportion of carbonic acid produced. The excess of this over that obtained by the last method of investigation will furnish the necessary data for the problem.

7. *Acetylene* is easily recognized in coal gas by passing it through an ammoniacal solution of the sub-chloride of copper, when a dark brown precipitate is formed of acetylide of copper. The experiment is before you, and I have started it by first putting into a double-necked bottle a little of the sub-chloride of copper already mentioned, and then, while the gas is bubbling through the liquid, and has displaced the whole of the atmospheric air in the bottle, I add an excess of a solution of strong ammonia, taking care that the liquid becomes perfectly clear, and of a deep blue colour. In this condition it will, as you here perceive, absorb acetylene and form the copper compound.

8. *Benzole and its series* are always discoverable in coal gas by passing it through a little of the strongest fuming nitric acid, whereby nitro-benzole, having the odour of bitter almonds, is quickly formed. I am here making the experiment in a small Liebig's potash apparatus, using a little water after the acid to absorb the fumes.

9. *Naphthalin* and *Anthracin* are not to be discovered in gas by any easy chemical test, although the former is sometimes present in such quantity as to form inconvenient deposits in those parts of the main-pipes which are exposed to cold.

10. *Ammonia.*—This impurity of gas is easily recognized by allowing the gas to blow upon a piece of moistened turmeric paper, when, if the proportion exceeds 2 grains per 100 cubic feet of gas, the paper is quickly reddened. The method employed for estimating the quantity of ammonia is to take a glass tube, about 8 or 9 inches in length, and nearly 2 inches in diameter, the ends being drawn out so as to fit it to flexible tubing. This tube is filled with small fragments of glass or with small glass beads, which are moistened with a known quantity of a standard solution of oxalic acid. The best proportion is a solution of 7·4 grains of crystallized oxalic acid dissolved in 100 septems of water. Fifty septems of this solution, representing 1 grain of ammonia, will sufficiently moisten the fragments of glass or beads in the tube. The tube must then be attached to the *inlet* of the meter, in order that no error may arise from the action of the water of the meter; and after passing 10 cubic feet of gas, the proportion of ammonia absorbed by the solution of oxalic acid must be determined by means of a standard solution of ammonia, and an alcoholic tincture of logwood (*hæmatoxylin*), which is sometimes improperly called hœmatine. This solution, when added to water, is yellow, as long as there is the least trace of acidity; but directly it receives the smallest excess of alkali it acquires a beautiful red or pink colour, and thus it becomes the means of ascertaining when the acid solution, which has been removed from the ammonia tube, is exactly neutralized by the standard solution of ammonia. Suppose, therefore, that 50 septems of the original oxalic acid solution, when coloured with tincture of logwood, required its own volume (50 septems) of the standard solution of ammonia to neutralize it—that is, to change the yellow colour of the hœmatoxylin to pink—and suppose that, after passing 10 cubic feet of gas, the 50 septems required only 25 septems of the standard solution of ammonia to change the colour, it is manifest that the rest of the ammonia (equal to that in 25 septems of the standard solution) must have come from the gas; and as the 50 septems of acid, as well as the 50 of standard ammonia, represent 1 grain of ammonia, there must have

been 0·5 of ammonia in the 10 feet of gas, and this is equal to 5 grains of ammonia per 100 cubic feet of gas. You may see from the experiment which I am now performing how delicate is this method of investigation, and the only precautions necessary are the making of the solution of oxalic acid and the testing of the standard solution of ammonia at the time of each experiment, as both of these solutions are liable to decomposition if they are kept.

Nessler's test is also a delicate test for ammonia—so delicate, in fact, that a quart bottleful of coal gas will generally betray the presence of this impurity, if it be agitated with 4 or 5 ounces of distilled water slightly acidulated with oxalic acid, and then tested with Nessler's solution of bichloride of mercury and iodide of potassium in caustic alkali.

11. *Bisulphide of Carbon, and other Sulphur Compounds.*—The recognition of these compounds is dependent on the combustion of a considerable volume of gas, and the collection of the sulphur products. It is generally done in the apparatus which I designed for the purpose many years ago, and which consists of a Leslie's burner, with a glass trumpet-tube for conveying the products of combustion into a glass cylinder, where they are arrested by condensation. There is also a contrivance for delivering the vapour, or rather the ammoniacal gas of the strongest liquor ammoniæ into the trumpet-tube immediately above the point of combustion. The gas is burned at the rate of about one cubic foot an hour, and the sulphur products, together with most of the water produced by the combustion of the hydrogen of the gas, are arrested in the glass cylinder. After burning for 24 hours, the experiment is completed, and the products are removed from the cylinder, and submitted to examination for sulphur. About one-fourth, or even, less of the liquid is evaporated to dryness in a weighed beaker or thin porcelain capsule, and in most cases the residue, which consists of sulphate of ammonia, with a very little nitrate of ammonia, will at once determine the proportion of sulphur; for every 10 grains of the residue (sulphate of ammonia) represent 2·42 grains of sulphur. In careful experiments, it is necessary to redissolve the residue in distilled water, and after making it hot, to precipitate it with a slight excess of a solution of chloride of barium, made slightly acid with muriatic acid. If the solution be kept boiling for a few minutes after the addition of the chloride of barium, the precipitate will be more easily thrown down; and after decanting the clear solution, and collecting the precipitate of sulphate of baryta upon a filter, washing with hot distilled water, and then drying and incinerating in a platinum crucible until the filter is burned away, and the precipitate left in a perfectly white condition, it is to be weighed, when every 10 grains of it represent 1·37 grains of sulphur. The precautions which are necessary to ensure accurate results with this apparatus are the following:—In the first place, the gas should always burn with a slight yellow tip to each of the jets. Secondly, the trumpet-tube should rest upon the arms of the burner, so as to prevent the escape of any of the products of combustion; and to ensure this I have found it necessary to enclose the jets of the burner in a perforated disc of tin or cardboard, which rests upon the arms of the burner, and supports the trumpet-tube. Thirdly, the trumpet-tube should have an opening at the larger end, which surrounds the burner, of from 3 to 3½ inches diameter, and the bore at the smaller end, where it is fitted to the cylinder, should be from 1 to 1¼ inch in diameter. Fourthly, the cylinder should be about 13 inches long, and 4½ inches diameter, with a neck at each end about 2 inches long and from 2 to 2½ inches diameter. Fifthly, the liquor ammoniæ used in the experiment should be of full strength, and not less than two fluid ounces in bulk; and, lastly, the temperature of the cylinder should be maintained as high as possible by covering the glass with a folded cloth. Very recently a modification of this apparatus has been proposed by the gas referees of London, whereby the products of combustion are more securely retained. The burner is a Bunsen jet, capable of consuming about half a cubic foot an hour, and it is enclosed within the trumpet-tube. Solid lumps of carbonate of ammonia are used in the place of liquor ammoniæ, and the cylinder is placed in an upright position instead of horizontal—the condensed products of combustion being allowed to flow off through a descending pipe. I find, however, that with the precautions which I have described, the results obtained by the old form of apparatus are strictly comparable with those of the new.

12. *Sulphuretted Hydrogen* is known by its action on lead paper, even when the impurity is present in a very minute quantity in coal gas—as, for example, in a millionth part of it; and this is the common test for it. Traces of sulphu-

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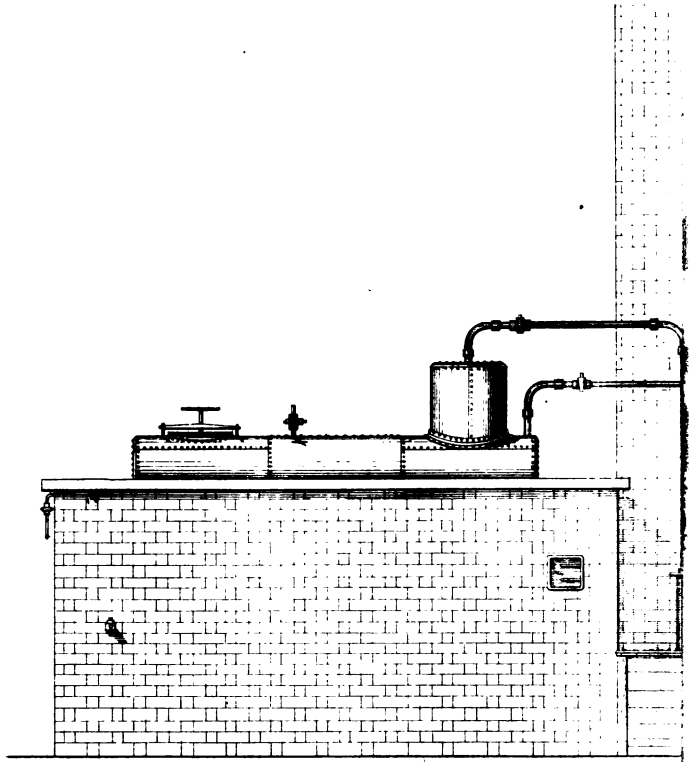

BOILER.

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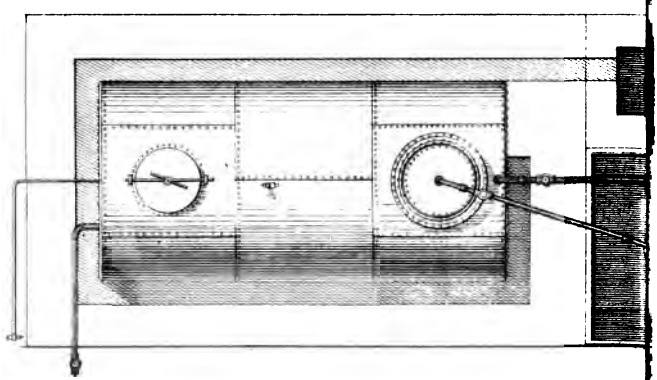


ELEVATION AND PLAN
SU

Litho. Whiteman & Bass London.

Jas Eld

retted hydrogen may be quantitatively estimated by means of a solution of iodine of known strength. The gas is measured by passing it through a meter, and then through a glass tube containing fragments of glass moistened with a solution of pure potash or pure soda; the pure soda of commerce, which is obtained by the oxidation of sodium in distilled water, is well suited for the purpose. When a considerable volume of gas has passed through the tube, the alkaline solution is treated, while still in the tube, and without exposing it for a moment to the air, with distilled water which has been acidulated with acetic acid, and boiled and cooled without access of air, as atmospheric oxygen vitiates the results. The solution, which must be acid, is then treated with a few drops of solution of starch; and by means of an accurately graduated pipette, a standard solution of iodine is dropped into the liquid until the blue colour of the starch ceases to disappear when the liquid is stirred. This indicates the point when the decomposition of the sulphuretted hydrogen in the acid liquid by the iodine is exactly complete, and knowing the strength of the iodine solution the proportion of sulphuretted hydrogen is determined. Larger proportions of sulphuretted hydrogen, as those in raw gas, may be determined by absorbents, as by means of a ball of peroxide of manganese, made somewhat compact by moulding it with water and drying it. An ammoniacal solution of chloride of copper will also absorb the sulphuretted hydrogen, and will yield flakes of sulphide of copper, which can be easily separated by decantation; and after conversion into sulphate of copper by means of nitro-muriatic acid, the proportion of sulphur can be readily estimated in the form of sulphate of baryta, as I have already described.

These are the principal constituents of coal gas, and you will perceive that although, in some cases, the quantitative estimation of them is difficult and troublesome, yet, in most instances, the chief and most important constituents are readily determined by processes which are quite within the reach of ordinary manipulative skill.

WEDNESDAY, JUNE 14.

The President took the chair at eleven o'clock this morning.

Mr. JAMES ELDRIDGE (Richmond, Surrey) read the following paper:—

ON THE APPARATUS FOR, AND METHOD OF, MANUFACTURING SULPHATE OF AMMONIA SUITABLE FOR SMALL GAS-WORKS.

When we met at Nottingham in 1867, Mr. Esson and Mr. Anderson read papers on the manufacture of sulphate of ammonia. I felt much interested in them, because the works of which I have the charge are nearly a mile from either river or rail, and we were for years obliged to dispose of our liquor at a loss; this led me to attach considerable importance to the valuable suggestions made by those gentlemen. Since then I have erected a small plant which has proved so successful that, with the permission of our committee, I beg to lay before you a brief description of it, with the results of its working.

My remarks are especially designed for the consideration of those who are managers of comparatively small works, who find their liquor a source of trouble, and the returns for which are not satisfactory.

Mr. ANDERSON says (page 14, report of 1867): "Numerous gas companies find their ammoniacal liquor a nuisance, and the respective communities they supply are universally getting more sensitive in the nose, so that unless it can be sold or given away, the question of what is to be done with it is becoming every day most urgent." This was just the case with us; we could sell it, but the price realised did not pay the cost of its removal from the works to the barge, and we were threatened with legal proceedings for conveying it through the village to the waterside. Some gas companies put it in their pits, with what destructive results I need not state. Some that I know dig a deep well and let it soak away into the earth, and eventually into wells in the neighbourhood.

I have had my small apparatus in operation about two years. There is nothing new in its general principles; it is much the same as Mr. Anderson's, shown in plate No. 5, in the report of 1867, and as described by Mr. Esson, page 20, when he says: "A step in advance of this arrangement is that one in which the liquor is pumped into a boiler. Along with the liquor, a proper quantity of shell-lime is put, which sets free the fixed ammonia. From this boiler a suitable pipe conducts the ammoniacal steam to a saturating vessel of proper construction,

lined with lead, and into which the sulphuric acid is put. The salts formed in the saturator are removed as they form, and more acid added as the case demands."

I do not say that the plan I have adopted is the most economical where you have to make a very large quantity, but I have found it has the following important advantages:—It is very simple, requires no steam, very little attention, and is free from offensive smell. I will now give you a brief description of it, with results as to profit, compared with our former mode of disposing of our liquor.

The gas is scrubbed with liquor till it shows about 7° of strength on Twaddle's hydrometer, or about 15 ozs. of liquor. It is then pumped into a settling-tank, from which it is conveyed through a pipe laid to a fall into a boiler 9 feet by 4 feet, which will work off about 500 gallons.

As it does not require a very great heat, the boiler is set over an ordinary furnace on a 4½-inch brick arch, so that no fire comes in direct contact with the boiler. Connected to the boiler, and leading to the saturator, is a 2-inch pipe, the top part of which is iron, and the bottom part is lead in the shape of a T, and is perforated.

The saturating-tank is then charged with brown acid of about 80°, the first charge of which is diluted with about 3 gallons of water to a hundredweight of acid; but afterwards we use mother liquor instead of water. Upon the application of heat to the boiler, the ammoniacal steam is driven over through the 2-inch pipe into contact with the acid. In about 18 hours the whole of the ammonia (or nearly the whole) will be driven over from the liquor into the boiler, and formed into salts at the bottom of the saturator; the spent liquor is then run off from the boiler, and the salts removed with the liquor into a cooling-pan, the saturator and boiler being again ready for charging in the same way. This occupies but a short time, and they are soon at work again. The salts are fished out of the cooling-pan and laid on a sloping tank lined with lead, the foot of the incline being perforated, so that the liquor may be drained from it and applied to the next charge. The process thus goes on every day except Sunday. As soon as the salts are sufficiently dry, they are put into a storeage-tank lined with lead, with an outlet at the bottom to carry off any small amount of moisture that may still be left in them; by this means we have no loss from the dissolving of the salts through damp weather and other causes.

In order to prevent any perceptible diffusion of objectionable gases, the saturating-tank is provided with a wooden covering, and in it is fixed a 6-inch pipe, the upper end of which is built into the chimney. The whole of the sulphuretted hydrogen is effectually carried off through this pipe into the chimney, so that there is really nothing offensive in the process.

Financially, the results may be stated in my case thus:—

To Acid	£160	0	0	By 34 tons sulphate at £15, less 2½ per cent.....	£497	5	0
Labour	25	0	0				
Fuel	10	0	0				
Profit	302	5	0				
	£497	5	0		£497	5	0

We thus realized a net profit of £302 5s., a sum not to be despised, particularly when we consider that it arose from the conversion of what might otherwise have been an intolerable nuisance.

Before I commenced, I not only studied the papers to which I have alluded, but visited several works where it was made, and in my opinion the process adopted by Mr. Stout, of Boston, was the best. Mine is very similar, differing only in a few details, which I think are improvements.

I am aware these few plain remarks on rather an important subject are not of that scientific character to which you are accustomed to listen on occasions like this, but I trust the few minutes occupied in reading this paper will not be vain, and that my endeavour to discharge a duty I feel that I owe to the association, by contributing, in however small a degree, anything of a practical character, that may possibly be of service to some one, will meet with your indulgence.

I think it desirable that our papers should be short, and I have not, therefore, gone so minutely into the matter as I might have done, but should any gentleman present wish further particulars, I shall feel a pleasure in giving him any information in my power.

Mr. Cox (Sunderland) asked how many tons of coal carbonized were represented by the £302 profit on sulphatemade.

Mr. Eldridge said about 6500 tons.

Mr. Baker said this was a subject in which he took a great interest, for he had been a sulphate of ammonia maker for the last 25 years. He found that from 1476 tons of coal he could produce 10¾ tons of sulphate.

Mr. Eldridge remarked that he had never heard of such a thing before.

Mr. Baker said he had a boiler which held 200 gallons, and he boiled it by steam. The ammoniacal gas came off with the steam very readily in seven hours. This appeared to him to be the only difference between his and Mr. Eldridge's process. He had used his present apparatus about 14 years. He was sorry that he had not taken out the financial details of the manufacture, so as to be able to lay them before the meeting; he could only say that the results were exceedingly good. He recommended every manager who had any difficulty in disposing of his gas liquor to work it up. There was no nuisance whatever in the operation, as the saturating vessel was covered over, and a pipe from it carried off the gas to the boiler.

Mr. Broadhead asked what was the strength of the liquor when Mr. Eldridge commenced to work it up.

Mr. Eldridge said he made his sulphate of about 16-oz. liquor.

Mr. Miles asked whether in a small work, where 1500 tons of coal annually were carbonized, it would be profitable to put up a scrubber, and use it for the purpose of getting a strong ammoniacal liquor.

Mr. Eldridge had no hesitation in saying that it would pay to put up a little apparatus. Mr. Miles said, "Put up a scrubber." He (Mr. Eldridge) took it for granted that there was no gas-work in existence, of any size, without a scrubber. On the previous day there was a remark made about scrubbing too much; for his own part, he would like to scrub much more. He was sure, from experience, that it was profitable in every way to thoroughly scrub the gas, and use the liquor over and over again, so as to get it up to 16-oz. strength. The scrubber very much assisted to remove a large quantity of impurity, which could not otherwise be got out of the gas. He had found that it answered well, in addition to the ordinary scrubbing, to take the liquor as it came from the hydraulic, and work it through the scrubber till it showed 16-oz. strength, and then to use a second scrubber with water.

Mr. Miles said at the works he was speaking about they had no scrubber, but a bell washer, consequently the water was not so strong as it might be. He had been told, in the course of conversation with a gas manager, that the very strongest ammoniacal liquor was not the best for making sulphate.

Mr. Eldridge said he liked to get it as strong as he could.

Mr. Anderson (Bath), from personal experience, believed that more salt could be obtained out of liquor of 5° Twaddle than of 12° Twaddle. The manufacture of sulphate of ammonia was a question which all managers—especially those connected with small works—should go into, because it could be profitably undertaken, and got rid of a nuisance. He manufactured his salts upon the same principle as that detailed in the paper just read.

Mr. Stout (Boston) said he had been engaged in the manufacture of sulphate of ammonia for many years, and he was always glad that he took it up. Before he commenced manufacturing the article the water was either lost, or given away, or destroyed, but he had long since found that it paid well to work it up. His experience taught him that the stronger the liquor the more sulphate he obtained in quantity and the better the quality. The process was a very simple one, and any manager of gas-works could take it up if he chose. He need not go to any great expense for machinery; all he required was a boiler, a saturator, and a drainer, and any one who was desirous to see the process of manufacture, was welcome to inspect his operations. It appeared to him to be a shame ever to allow an article of such value as ammoniacal liquor to be destroyed. His own opinion was that there was a good time coming for sulphate makers, inasmuch as the supplies of Peruvian guano were failing. Gas liquor contained the same fertilizing agent—ammonia—and it was already fetching an excellent price in the market. If he could make twenty times the quantity he had hitherto done he could dispose of it at £19 a ton. He did not make the very whitest salt, because he sold to manure makers, who looked rather for quantity than quality.

Mr. Craven asked Mr. Stout how many tons of coal he carbonized, and the number of tons of sulphate he obtained.

Mr. BAKER said the process he adopted was very simple. At present he drained through baskets, but the best way was to drain into a wooden tank lined with lead.

Mr. CHURCH asked whether he used Newcastle coal.

Mr. BAKER said the results he had given were those of the last four months, and during that time he had been using some Welsh coal, a little better than he obtained in former years; but generally he used Newcastle coal.

Mr. CRAVEN asked whether he got 11,000 feet of gas out of Newcastle coal.

Mr. BAKER said he did with Londonderry coal, No. 4 seam, using high heats, and taking care that the dip was properly regulated, so as not to get undue pressure.

Mr. STOUT said his works being now in process of rearrangement, he had not, during the last few months, the opportunity of carrying on the sulphate process so regularly as formerly. During the last entire year his production was rather over 30 tons of sulphate, and the quantity of coal carbonized something short of 5000 tons—say, 4800. He charged his sulphate account with labour and carriage, and indeed every expense that legitimately belonged to it, and, on making up accounts at the end of the year, he found he had made a profit on the manufacture of £250.

Mr. KELSALL said there seemed some misconception respecting the strength of liquor which was preferable for the purpose of making sulphate. A chemical agent recently told him that he preferred 6° Twaddle liquor unscrubbed to 12° Twaddle scrubbed. As to the advantage of scrubbing gas, there could be no question in the minds of those who had had any experience in the matter. If Mr. Myers would go to the expense of erecting a scrubber, he would find that the benefit in the purification of his gas alone would repay the outlay.

Mr. BROADHEAD said at his works he did not manufacture sulphate, being under contract for five years for all his liquor. In his present contract he was bound to deliver it of 5° Twaddle; formerly it was fixed at 4°, which was about the strength at which it left the hydraulic. By putting it through the scrubber it was brought up to 6° and 6½°, and the purchasers did not mind how high it was raised.

Mr. R. P. SPICE said the subject introduced by the paper for discussion branched out into so many topics that it was difficult to compress the remarks he desired to make into any reasonable limit. With regard to the apparent discrepancy in the statements made, he might point out that Mr. Baker appeared to have taken four months experience with a particular kind of coal, and to have estimated the return for the year on that basis, rather than to give an actual result throughout twelve months. Referring to the returns given by Mr. Eldridge and Mr. Stout, it would seem that where operations were carried out for converting the ammoniacal liquor of gas-works into sulphate of ammonia there was a profit of about 1s. for every ton of coal carbonized. It had been said that under some circumstances a return of something like 2s. per ton was attainable. This was a large result, and came very nearly up to what Mr. Baker mentioned. There were a variety of ways of accounting for differences of such an extreme character. He (Mr. Spice) had paid a great deal of attention to the subject of scrubbers, and the result of his experience and observation was that, as a rule, they were either too low or too wide—that the diameter was too great, or the height not great enough. It was necessary that the scrubber should be so constructed as to give a shower of liquor (not water—he abhored water in gas-works, for when used it threw down the hydrocarbons contained in the gas, whereas when liquor was used the illuminating power was not deteriorated, and no offensive results ensued). Every gas manager might with safety bring up the strength of his liquor by passing it through a scrubber designed to suit his works, to 18 ozs. Mr. Stout had now a more powerful scrubber on his works than formerly, and no doubt he would be able to show better results during the next twelve months. With regard to the use of scrubbers generally, a previous speaker asked whether it was worth while to put up one for the sake of making the ammoniacal liquor stronger. He (Mr. Spice) could not understand why any gas-works should be without a scrubber. He did not think much of the use of water in a still, as the particles of gas did not come effectively in contact with the particles of water. He preferred a continuous shower of ammoniacal liquor through a scrubber. The scrubber at Mr. Stout's works was 30 feet high and 10 feet in diameter, and there was a constant stream flowing through. There were five sieves, and the material employed was 9 inches in depth, composed of broken glass and pottery ware. The space between the

surface of pottery and the bottom of the next sieve above it was for the gas to tumble about. This he held to be a valuable point, for the gas should have room to twist and turn about, so that every particle of it should come in contact with the liquor, and become thoroughly wetted therewith. It was next to impossible to work a scrubber properly without the aid of steam, or it would become choked with tar, thus increasing the pressure on the retorts and otherwise become objectionable. A small steam apparatus could be put up at a comparatively trifling expense, and be worked without any cost. However small works might be, it was desirable to have a scrubber and a steam-engine, and having these he did not see why there should not be also an exhauster. Step by step he had arrived at the conclusion that the right things to have were clay retorts, exhausters, and scrubbers, and that where the liquor could not be sold it should be converted into sulphate. Gas ought never to be sent out now-a-days, as it sometimes was, charged with ammonia. The ammonia ought to be kept at home and utilized.

Mr. PRICE said he had followed out a plan very similar to Mr. Eldridge's, and having calculated cost and returns, he found that he realized a profit of cent. per cent. He wished Mr. Eldridge to inform the meeting what means he employed for getting rid of the fumes arising from the manufacture of sulphate of ammonia.

Mr. STOUT said he omitted to make one remark which he had intended as an encouragement—viz., that it frequently happened there were other small works to be found in the neighbourhood, the managers of which would be glad to sell their liquor at a low price, so as to make it worth while to undertake this branch of manufacture. With reference to the discrepancy in some of the statements made as to the amount of profit upon the article, a great deal depended upon the way in which the result was arrived at. One manager, perhaps, did not charge labour, fuel, and carriage against the receipts, whereas another probably included every item of outlay, which, of course, was the proper mode of determining the value of the process.

Mr. GREENFIELD (Torquay) said, from what he gathered in the course of the conversation, Mr. Eldridge worked up to 12 and 16 oz. liquor. Perhaps the gentleman who spoke on the other side had two scrubbers, and passed through the second the liquor which had been through the first. He would be glad to learn whether any of the members had had any experience in sending jets of steam through the apparatus.

Mr. LANE said it appeared to be taken for granted that there were great discrepancies in the results. He could not see that there were any, and he believed the apparent differences arose from the different qualities of coals used. It would seem that Mr. Baker made a little over 6 tons of sulphate per 100 tons of coal carbonized, which was about the same return as that obtained at Boston. The whole difference really amounted only to 10 per cent., which, as he said, might easily be accounted for by the variations in the coals, and probably by a more elaborate system of washing.

Mr. HODGSON JONES rather differed from Mr. Spice as to water not being allowed to come in contact with gas. He was accustomed to scrub gas with liquor through two scrubbers in the manner described, and after that he passed it through a third scrubber, in which water was employed. He found in many towns to which he went that there was ammonia in the gas. Where lime was used for purification there was no fear of taking too much of the ammonia out.

Mr. G. ANDERSON said he was about the first person to manufacture sulphate of ammonia from gas liquor in London, having commenced it at the Surrey Consumers Gas-Works 18 years ago, when other managers were sending it away in barges. The process which Mr. Eldridge had described was a nice, simple, and easy one, which almost any gas manager could adopt. There was only one very small objection to it—viz., that, unless there was a water-trap, the products which came from the saturator and ascended the chimney were liable to explosion, and that, in any case, the combustion of those gases in the chimney caused an unpleasant smell, sometimes not so much at the works as at a short distance from the works. There was a mode of getting rid of that objection, which was this: instead of causing the vapours to pass from the close saturator into the chimney, to condense them, as was done in a highly satisfactory manner at the Crystal Palace District Gas-Works. They might all be reduced into a dirty curious liquid, the exact elements of which chemists had not yet defined. A difference of opinion had been expressed as to the proper strength of the liquor—*i.e.*, whether sulphate could be best prepared from a heavy or light

liquor. He quite agreed in what had been said as to the value of the liquor to the manufacturer being greater in proportion to the quantity of ammonia it contained per gallon, if the liquor were not too strong; but, from experiments he had made lately, and which had been subsequently confirmed, he was prepared to state that, if sulphate were made from very strong liquor—say, of 20 to 25 oz. (which it might be by washing and scrubbing)—it required from 30 to 40 per cent. more acid per ton of sulphate made than if a weaker liquor were employed. He did not mean to say there was any ammonia lost, inasmuch as a gallon of strong liquor would make more than a gallon of weak. The number of gallons of liquor necessary to make a ton of sulphate would be more with weak liquor than with strong, but the number of pounds of acid to make a ton would be less with the former than with the latter. The explanation of this might be that there were acids in the liquor which assisted in the manufacture—carbonic acid was one—and that with all the washing and scrubbing which might be given to the gas, the proportion of these acids was no more whether the liquor were strong or weak. He was sorry to differ from Mr. Spice, but he was bound to say he was totally at variance with him as to the value of water in washing gas. He could say all that Mr. Spice had said, but he must say it with a circumstance. He could say that the washing of gas with pure water threw down the hydrocarbons, but he must add that this arose from washing with an improper quantity. He had after many years experience arrived at the conclusion, and he was perfectly confident on the point, that nobody should think of saying his gas was purified after simply washing it with ammoniacal liquor. On this point he would speak as strongly as possible. He asserted that when gas had become nearly purified from ammonia, to bring it into contact with a liquid highly charged with ammonia, it was much more likely to take ammonia from the liquid than to yield up any small remaining portions it might previously have contained. The way to purify gas was first to condense it well, having as little use for steam in the scrubber as possible; then to introduce it into the ammoniacal liquor of the works, which he would suppose to be about 5° Twaddle, requiring 10 ozs. of acid per gallon to neutralize it. If this were done the water in the washer would increase in strength so as to require nearly double the quantity of acid to saturate the ammonia. In his practice the gas was passed from the washer through a scrubber supplied with pure water at the rate of 10 gallons per ton of coals carbonized—or, in other words, about double the volume of his ammoniacal liquor. This 10 gallons he could not put on in a constant stream, because such a stream would be very small and would do very little good, as it would trickle down the interstices of the scrubber, finding for itself a passage in the easiest way; while the gas would pass up where there was least resistance, and consequently come but slightly in contact with the water. He therefore supplied the water as a douche by means of a self-acting tumbler, on the principle of a Barker's mill, by which he obtained a very equal distribution of the water, and he found that going in at the top of the scrubber pure it came out at the bottom 5 or 6 oz. liquor. That liquor ran into the ordinary ammoniacal liquor-tank of the works, and was a part of that which, in subsequent operations, was pumped into the washer. On the previous day, it was mentioned that at his old works, at Dover, he did not employ the apparatus described, and that the difference between the gas from the old and new works could be always observed, although the gas was made from the same coal and purified in the same manner. Clearly, therefore, the hydrocarbons were not thrown down by the use of pure water, because at the old works it was not used and at the new works it was.

Mr. GARNETT said in the works under his superintendence, at Ryde, he was placed in such a position that he was not permitted by the local board to manufacture sulphate. But with reference to the value of scrubbers, and the pumping of ammoniacal liquor through them, he might mention that, when he had occasion to stop his pumping apparatus for repairs or otherwise, he found an increase of one-third in the cost of his purification. In answer to Mr. Foulis, he stated that he was obliged, from the circumstances in which his works were conducted, to purify by lime, as there would be a strong objection in the locality to the revivifying of oxide. His purifiers were all on the upper floors, with openings in each floor, and at five o'clock in the morning he had to get carts for miles round sometimes to remove the refuse lime.

Mr. ELDRIDGE, in reply, said a part of the discrepancy between the returns of sulphate spoken of might be accounted for by the fact that last year, in consequence of great difficulty in disposing of tar at his works, he threw away enough

liquor to make a couple of tons more than he had shown. This year, during the first five months, he had made 20 tons, so that the results would be more favourable. With reference to Mr. Price's inquiry, he might state that when he first started his apparatus there was sometimes a little offensive smell, and one or two complaints reached him from persons half a mile from the works. No doubt in dense weather there would be a slight smell from the chimney. He had thought that this might be remedied by having a pipe brought from the cover of the saturator into a trough of water with a dip, and a little burner on the top of the pipe to burn off any gases. The suggestion made by Mr. Anderson on this point was valuable, and he was thankful so much information had been elicited during the discussion.

Mr. WARNER read the following paper:—

ON THE BEST FORM OF CARBONIZING ACCOUNTS.

In the consideration of this subject it may be best to look at the *work* itself, of which an ordinary carbonizing diary is but a very imperfect record. The work of a gas company naturally resolves itself into three distinct departments, more or less connected according to the extent of the establishment and administration of its affairs. The three are "Accounts," "Manufacture," and "Distribution." The account, however, as far as the *cost* of keeping them is concerned, is fixed, or only variable from year to year, and therefore need not be further noticed.

We have, then, the indoor and outdoor work to deal with, and these are ever varying with the seasons and districts lighted; hence the necessity of a *constant watchfulness* over the work, that its COST may be kept at a minimum. This watchfulness is not that of an incessant personal attendance at the work—practised in the full belief of the truthfulness of the old proverb, "While the cat's away the mice will play"—but a watchfulness like that of the German general, which will allow the manager to sit comfortably in his office while working out the desired object—the largest possible balance at the end of the half year—and with the full assurance, too, of its being attained. As the *whole* of the work must be watched, and as this must be done constantly, it is necessary to have it epitomized and brought together, that the whole may be seen for comparison, and, if necessary, adjustment or correction; in other words, the COST PRICE *of the whole of the work* under *each separate and distinct class* must be worked out *periodically* and at *short intervals*, and *compared with corresponding previous workings*, and systematically arranged under proper headings showing the *actual* and *comparative cost* of the *labour*, *material used*, and *work done*, and the *cost per* 1000 *feet of gas made*. Copies of forms of account arranged upon this principle, and used at the South Shields works, are placed upon the table for inspection.

There are two sheets, one "The average and comparative cost of gas per 1000, with weekly report of working," and the other is "The average and comparative cost of the distribution of gas per 1000, with report of work." In the first of these we have "Date, number of retorts in action, number of firemen;" and then, under the general heading of "Wages as per wages-book," there are the sub-divisions of "Firemen, coal and coke, engines, purifiers, totals, and cost per 1000 feet made; total wages corresponding week, and cost per 1000." Then follow columns, "Gas made, last year's make, coals and cannel used, yield per ton, cost per 1000; yield last year, and cost; lime and cost, carting and cost, (goods) incidentals and cost;" and then, under two columns, are the wages paid for "Repairs and miscellaneous work," and then the "cost." Following is the "Total cost of distribution per 1000," obtained from the "Distribution sheet." As the total cost per 1000 is what is principally aimed at, all the "cost per 1000" columns are written in red ink, and so are easily cross-cast to arrive at the "Total cost per 1000 feet of gas made, for which the next column is prepared. The remaining columns are "Illuminating power, sulphur in gas, and cost of gas per ton of coals carbonized," for comparison with those who work out the cost upon this principle. The other, or "Distribution sheet," has after the date column a similar wages arrangement as that just described, with columns for "Mains, inspecting, meters, lamplighting, lamp repairs, totals, cost per 1000, and corresponding totals and cost per 1000." Columns for the work then follow. "Meters fixed and disconnected, services laid and relaid;" and under the gene-

ral heading of "Public lamps" we have the "Number lighted, number reported out by police, number of lanterns repaired, and number of services relaid," and then under another general heading, "Complaints." These are arranged in the order of "Services, meters, escapes, consumers;" following are the "Materials used in each class of work," in separate columns, thus: "Mains, services, meters public lamps, totals, cost per 1000, and corresponding cost," and then the "Total cost per 1000," and its corresponding column.

In keeping these sheets, all the principal or important items are worked out week by week, and they are also cast at the end of the last week of each month, and the averages obtained, two lines being left under the totals to show the increase and decrease in the averages of the month's working. Thus the work and its cost are arranged for comparison, and by this means a perfect watch is maintained; any increase being at once shown, not only in the general cost, but also in that branch of work in which it takes place, and this can then be immediately compared with the work column to see whether it is proportional, and the result of this extra work well repays the trouble. To some the arrangement may appear too highly elaborated; yet, if properly worked and well kept up, it is not at all troublesome. For instance, after the first year's working, the previous one has only to be copied, and this, to prevent confusion and mistake, is done in blue ink under the same coloured headings, and previous to the commencement of working the sheet. The wages are entered direct, week by week, from the wages book; and the work done and materials used are entered from a sheet containing a weekly abstract from the books in the several departments; the cost per 1000 being worked out in red ink, to prevent mistakes and facilitate the cross-casting by the manager.

For this system it may be said that it has not been theoretically arranged, but that it has gradually assumed its present form item by item, and column by column has been added as the want has been felt. It is now deemed *essential* to the *thorough working* of the concern, from the check it keeps upon the cost and working; each cost being worked out, too, to three places of decimals, the least increase or decrease is at once shown, and the attention immediately drawn to any irregularity of working either indoor or outdoor. Beyond this the manager becomes thoroughly acquainted with the *value* of every item of the work; and so, instead of groping in the dark through each half year, week by week, his work *is managed*, and so he can look forward to the striking of the balance with confidence, knowing that the company has realized full value for its expenditure.

The PRESIDENT stated that Mr. Niven, of Clayton, who was to have read a paper on the same subject, was not present, but he had sent some specimen sheets of his mode of keeping such accounts, which could be examined by the members.

Mr. HODGSON JONES said there was one point in connexion with this subject which was very interesting to gas managers, and that was the method of ascertaining correctly the unaccounted for gas. At a great many works which he visited this was done in a very rough manner. The system he generally adopted was to have a consumers ledger, in which the consumption per meter was taken on each side of the page either monthly or quarterly, and he had found it furnished an extra check upon the state of the meters. The question of meters was often very complicated, and it was difficult to arrive at a just conclusion respecting it.

Mr. R. H. JONES had had some little experience in accounts, and confessed that he was frightened when he looked at the formidable specimen sheets laid before the meeting. He was manager of five or six works, and had weekly returns from each. The totals of these works were summarized quarterly, and the quantities of gas sold in the three months were ascertained; also the quantities of coal used; and thus he got at the consumption and the leakage. He had no comment to make upon the sheets now produced except that they were too formidable, and he should not like to put them into any one's hands except those of a professional accountant.

Mr. BROADHEAD said they had each their own mode of keeping accounts but he had no doubt they all proceeded much upon the same principle.

Mr. WARNER, in reply to Mr. Spice, said the reason why he took the cost per 1000 feet was that, in so doing, there was always something to lay hold on. The cost per ton of coal carbonized was liable to error. He could assure the meeting that there was nothing really complicated in the form of accounts pre-

sented, and that they could be practically adopted with great facility and advantage. The principle was to work out every item per 1000 feet made, which gave always a real standard of comparison.

The HONORARY SECRETARY read the following paper:—

ON COAL STOREAGE AND SPONTANEOUS COMBUSTION OF COALS.

By Mr. A. H. WOOD, of Hastings.

The object of the present paper is not to attempt any elaborate description of the chemical transformation that takes place by spontaneous combustion, or to bring before the association matters which can be considered anything more than many of its members are better acquainted with than the writer, but to give a nucleus for the discussion of a subject which is important to every gas manager where from local circumstances the storeage of a winter's supply of coals is absolutely necessary.

There are no doubt many gas-works where the large storeage of coal is not so requisite as others, but there are works, and I presume the majority, where it is absolutely necessary to have a good "nest-egg" of coals for the winter. Such is my own case, and I know of many others who are similarly situated.

I am decidedly of opinion where the continuous supply of coals from the collieries can be safely relied on, that there is a considerable saving in the carbonization; and although I have heard it argued that coal loses nothing by storeage, my experience goes to prove that there is a loss of value, either in yield or illuminating power, varying from 5 per cent. to 10 per cent., or even more, in long-stored coal, over the same coal received in good condition direct from the colliery.

There are, however, certain conditions which no doubt vary the losses which take place in warehoused coals—the original size of the sample of the coals, the grinding of them in warehousing and trimming, the tenderness of the sample, and, most particularly, the chemical constituents of the coal itself, some coal being much more tenacious than others, and these most probably suffer least. Enough, however, has probably been said in this digression to prove that the storeage of the coal *in good condition* is a subject worth consideration.

One of the most important points, however, in association with the storeage of coal is its liability to spontaneous combustion. Vessels have sometimes been lost with all their crews from this cause alone, and many gas managers have found large stores of coals dangerously heated, while others have gone a step farther and found them actually fired.

It should be the object, therefore, of every gas engineer, where a large store of coal is absolutely necessary, to see that they are carefully stored, and that such precautions are taken as to lessen the danger if not altogether prevent the possibility of spontaneous combustion. With a view to this end, let us just for one moment inquire into the cause of such a calamity, and it follows that if we can discover this we may then with a greater facility prescribe a remedy.

One of the most important causes (if we may not say *the* cause) is the presence of iron pyrities, and their absorption of atmospheric oxygen.

It appears that the white pyrites are more dangerous than the yellow, because they contain a mixture of protosulphuret and bisulphuret of iron, the proportions of which, according to three eminent analysts quoted by Brande, are as follows:—

Protosulphuret of Iron (*Fe* + *S*).

		Combining Proportions.	Hatchett.	Berzelius.	Proust.
Iron	1	28	63·5	63	62·5
Sulphur . . .	1	16	36·5	37	37·5
Protosulphuret of iron	1	—	100·0	100	100·0

If we look at this analysis for practical purposes, we shall see that about one-third part of this protosulphuret of iron is composed of pure sulphur, the average running out at 37 per cent.

Let us now look at the other ingredient, named bisulphuret of iron; here we find a still more dangerous compound, as its combining proportion is two of sulphur to one of iron (Fe + 2 S), the analysis given of three eminent chemists being as follows:—

		Combining Proportions.	Berzelius.	Hatchett.	Buchold.
Iron	1 ..	28 ..	46·08 ..	46·70 ..	49·00
Sulphur . . .	2 ..	32 ..	53·92 ..	53·30 ..	51 00
Bisulphuret of iron	1 ..	60 ..	100·00 ..	100 00 ..	100·00

The quantity of sulphur in bisulphuret of iron (taking the average of these three chemists) being 52·74, and the evidence of Mr. R. D. Thomson, as quoted by Muspratt, is very similar to his analysis of coal:—

Sulphur	53·35
Pyrites, being iron	45·07
Impurities.	1·58
	100·00

Let us now inquire what takes place when these combinations absorb atmospheric oxygen; in the first place, the oxygen in combining with the sulphur forms sulphurous or sulphuric acid, and in combining with the iron to make oxide of iron, and these combining again to form sulphate of iron, during which combinations chemical heat is evolved to a greater or less degree.

I am indebted to Dr. Letheby for a very lucid, exact, and concise description of these transformations. The doctor says: "The white pyrites of the coal are a mixture of proto and bisulphuret of iron; these undergo oxidation on the access of atmospheric oxygen, and the protosulphide of iron is converted into ferrous sulphate ($Fe\,S\,O^4\,7HO^2$), which is accompanied with sufficient heat, when the action is confined in the mass, to effect the further oxidation of the bisulphide of iron, and thus at last the heat rises to such a pitch as to fire the coal."

There is nothing peculiar in this generation of chemical heat during these transformations, as it is only an ordinary auxiliary in chemical combinations. Almost all oxidation is accompanied by it in some degree, the degree being dependent on the energy with which the combination takes place. Muspratt (vol. i., page 157) gives a very excellent account of the "spontaneous rise of temperature" by the decomposition of iron pyrites used in the manufacture of alum. The same thing also takes place by the use of them for the manufacture of copperas, and a similar action is familiar to every gas manager in the revivifying process of the oxide of iron where used as a purifying material.

Now it is well known that iron and sulphur (the two prominent elements in pyrites) both absorb oxygen with great vigour; in the first place, to form, as before stated, sulphate of iron, and in the second place, sulphurous or sulphuric acid, consequently a great deal of heat is evolved, sometimes (especially when the quantity is large) sufficient to fire the coal, but as in more ordinary cases to considerably raise its temperature.

Now what is the practical inference to be drawn from this? If we know that the master cause of spontaneous combustion is from the presence of pyrites, why allow them to be stored with the coals? why not pick them out as they are being stored? It is not a difficult task, and carters, trimmers, coal wheelers, and stokers are all willing to do their part (for a trifle per bushel), and jealous even of each other as to the quantity procured. I have now done it for some years, and have never found my coal heated since, to say nothing of an unquestionable advantage in the purifying process.

Another important feature in the storing of coal is that it should be stored dry. To say nothing of the inconvenience of having a lot of wet coal come out in the winter to knock down the heats in the retort-house, it is an acknowledged fact that damp or moist coal facilitates the condition of things that I have been discussing—in fact, that moisture in the coal or in the atmosphere to which the coal may be brought in contact tends to increase, if not at first set up, the oxidation of the white pyrites, and consequently chemical and spontaneous combustion. Brande, Muspratt, and Dr. Letheby, and in fact all who have given much attention to the subject, hold this view, and I believe it is the practice, in the manufacture of sulphate of iron from pyrites, to throw them in a heap and moisten them with water to facilitate the very oxidation which every gas manager would seek to prevent.

It follows, then, I think, from this that coal should be stored as dry as possible. I am quite aware that sometimes it is not easy to prevent damp coal being stored, but still something may be done by every manager to lessen, if not altogether prevent, the storing of damp coal.

One means that I have found to assist this end is to keep one warehouse for a more general store than others; in this store I work, both in and out, all the summer. If a sample of coal is not so good or dry as I could wish, it is put here, and used up quickly, only that which is thoroughly satisfactory being stored up for the winter. I am quite aware this cannot always be carried out, but I throw out the hint as being one means of getting a dry stock for the winter where it is practicable; and where it cannot be altogether carried out, it may partially, and even then it may be useful in preventing the coal from heating.

There is one other point I will just allude to—viz., that the warehouses should be so situated that they should not be subjected to any auxiliary heat. I am quite aware that this remark will not apply to factories of any magnitude, but in many small and medium-sized works the coal warehouse sometimes adjoins either the retort-house, a boiler-room, a smith's forge, or something similar, and the auxiliary heat through the wall tends, especially with damp coal, to set up the oxidation. I know one instance where it was unquestionably the case, and I therefore here just throw out the hint.

Having now said sufficient to evoke a discussion, I will, in conclusion, simply repeat that it is my belief, if the pyrites are carefully picked out, the coals stored dry, and auxiliary heat cautiously avoided, we shall not be troubled much with spontaneous combustion in our coal-stores.

Mr. Hodgson Jones regretted that Mr. Wood, in his paper, had not touched upon the question of the ventilation of coal-stores. It was an important matter, as, in his experience, he had known cases of combustion arising entirely from the want of sufficient ventilation. So far was it an admitted fact, that in France the insurance companies would not issue policies to cover stocks of coal, unless due attention had been paid to the proper ventilation of the stores.

Mr. Baker said, having had a coal-store on fire containing 800 tons or more, his attention had been forcibly drawn to the question of how to prevent the recurrence of such a calamity. He had found a very effectual means was to put down a number of empty hogsheads, here and there throughout the store, at the time the coals were laid in. This promoted ventilation, and the men were enabled to go down from time to time, and detect if there was any heat.

Mr. Fraser said, as a coal master and a shipowner, he had had some experience in this matter. Welsh coal was specially liable to spontaneous combustion. On one occasion he had a load of coal lying alongside another ship in a Welsh port. The hatches in the last-named ship were put on night after night, and the consequence was that gas was generated, and the hatches were blown up. In his own ship the hatches were kept open, and a good deal of rain fell upon the coals. The captain took the precaution to use ventilators, consisting of long perforated tubes; but, before the vessel arrived at Alexandria, heat had been set up, and a part of the coal was almost on fire. Scotch coal was little, if at all, liable to spontaneous combustion. He never knew an instance of Fife-shire coal taking fire spontaneously, but after the seams were pretty well worked out, spontaneous combustion frequently took place. At the bottom of many of the pits there was a good deal of iron pyrites; and, though this did little harm of itself, the bed of shale overlying it sometimes fell, and then heat arose, the small coal around evolved gas, and in this way spontaneous combustion was set up. The miners had the first intimation of it from the white damp, which had a most poisonous effect upon them. It did not affect the lights in any way, but had a soporific effect upon the men. In consequence of the possible presence of this white damp, it was found absolutely necessary in some places, after the coal was taken out, to bring to the surface also all the pyrites; then no spontaneous combustion arose. With regard to Scotch coal generally, the only liability was to choke-damp, which put the lights out. He had had 40,000 tons stored for a long time, and it never entered into his head to take any precautions against combustion, and he believed it arose very much from the fact of the small proportion of sulphur in Scotch coal. In order to detect the approach of spontaneous combustion in his coal-stores, Mr. Woodall, at the Phœnix Station, Vauxhall, put iron rods down through different parts of the coals. These rods were occasionally drawn up, and, if they were found to be heated, measures were taken to stop the combustion.

Mr. Hodgson Jones said he used baskets without bottoms to ventilate his coals, and he dropped a thermometer down them every morning to try whether

heat was being generated. This was a more convenient means of detection than an iron rod.

Mr. BROADHEAD asked whether it would not be well to employ 8 or 9 inch pipes perforated with holes, and with good broad bases, and stand them up in various parts of the stores, so as to keep the whole ventilated.

Mr. H. JONES said that plan had been tried, and it was found, in several cases, that these pipes acted as chimneys, and the whole of the coal was burnt if combustion set in. If there were a fire in a store where baskets were used, the coal on the top falling in would choke the flame.

Mr. OHREN wished to say a few words in favour of ventilation. At his works at Sydenham he had twice had the misfortune to have coals on fire. About £150 worth of coal was destroyed, but the loss did not fall upon the company, as the coals were insured, and they received the whole value from the office. For the last three or four years ventilating-shafts in the coal-stores had been used, and it was found by that means that if the coal was at all inclined to fire the gases passed off through the shafts. In fact, the result was perfectly satisfactory. He did not at all understand why, if 9-inch pipes were used as ventilating-shafts, as Mr. Broadhead suggested, the coal should be more liable to fire. Mr. Jones said they would act as chimneys and create a draught, which would increase the liability. In his stores the ventilating-shafts were made 2 feet square, and they were placed 25 feet apart all over the stores.

Mr. H. JONES said he made his remark under the supposition that Mr. Broadhead meant vertical pipes.

Mr. BAKER said that if the shafts formed chimneys, there must necessarily be ventilation, because the cold air would come in at the bottom.

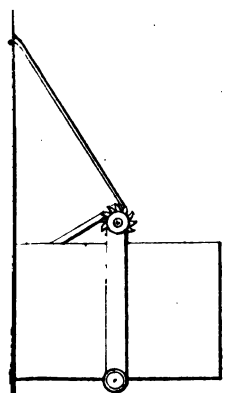
After a short adjournment for luncheon,

Mr. HARTLEY (Westminster) read the following paper:—

ON GAS MEASUREMENT.

The tendency of recent legislation on gas matters appears to lie in the directions of an increase in the illuminating power and of a diminution in the selling price. It follows, therefore, that dividends have now, and will in the future have to be realized upon gas yielding a smaller per centage of profit on its cost than that obtained in days gone by. Gas manufacturers have not been wanting generally in earnestness and industry in seeking to lessen the cost of production, and to a certain extent their efforts have been rewarded; but, judging from experience, and with our present knowledge of the subject, it certainly may be assumed that so long as it continues necessary to produce gas mainly or entirely from coals, its first cost will not be brought materially below the present standard in well-conducted works. It is, therefore, a manifest fact that if, at reduced selling prices and enhanced quality, the full dividends are to be secured, they must be realized by bringing the largest possible proportion of the gas made into charge. Most companies are to a greater or lesser degree sensible of this, and by careful attention to the condition of mains and services, and to the adjustment of the supply pressures during the day and night to the requirements of the consumers, and also by the application of regulators to the public lights, have effected important reductions in the per centage of unaccounted-for gas; but there is yet another part of the distributing apparatus which has not yet received the attention which it deserves —namely, the measures by which the consumption is estimated.

The gas-meter, whether wet or dry, is such an admirable machine, and does its work generally so well, while demanding so little attention, that it seems as though it were sometimes forgotten that the meter is, after all, only a production of mechanical ingenuity, and, like all other machines, requires a certain amount of supervision and correction. Every practical man must be cognizant of the difficulty, nay, the impossibility of producing machines, whatever be their character, which shall be perfectly free from liability to derangement, and it is in the highest degree absurd to expect that the gas-meter should be so pre-eminently perfect as to be exempt from the frailties which are inherent to the offspring of human ingenuity. Yet the author has known of hundreds of cases in past days in which wet meters have been allowed to remain for long periods in use with a deficiency of water in them, and of dry meters being continued in use long after they must have become imperfect, and even in a practical sense worn out. It is true that the limited water range now permitted compels a more frequent and regular attention to wet meters, but still sources of derange-



's method.

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ment exist; and it is notorious that if a dry meter be continued in action too long uncleaned, it is susceptible of changes which may seriously prejudice the interest of the seller of gas. That such things as these are true in no way militates against the reputation and trustworthiness of the instruments when rightly regarded. Probably there is no other automatic machine which receives and really requires so little attention, does its work so easily, and, as far as circumstances will permit, so satisfactorily, as the gas-meter. Yet this machine is, unfortunately, a prolific source of discord between the buyer and the seller of gas, and simply, it seems, because too much is expected from it, and because in addition the unscrupulous assertions of agitators and of some unwise meter-makers, have excited the distrust of the public, who have been led to look upon gas-meters as mere "conjuring boxes," which the companies could, at will, cause to indicate large or small (generally large in the public mind) quantities of gas irrespective of consumption, by some mysterious operation of "pressure;" although what pressure means, or in what way it can affect the action of a gas-meter, the public remain in profound ignorance in spite of all the efforts which have been made to enlighten them.

It thus came about that, almost *pari passu* with reductions in the price of gas, and therefore, in an economic sense, the lesser need to the buyer for its exact measurement, the public distrust grew in strength; and this distrust has been but partially allayed by the operation of the Sales of Gas Act, which was passed in the year 1859, and modified by two subsequent Acts. Gas companies and meter-makers generally were quite disposed to welcome any Act of Parliament of a nature calculated to relieve them from unjust suspicion, and at the same time protect the interests and satisfy the minds of the public. Unfortunately, the Sales of Gas Act was, and still remains, a very imperfect measure, in spite of the efforts made at various times by gas companies and meter-makers to obtain such alterations in it as would render it really efficient. It is true that the Act has to a considerable extent served the purpose it was intended to accomplish; but that it has done so is due almost entirely to the intelligence, common sense, and integrity of the inspectors who have had to carry its most important provisions into effect.

The Act is full of imperfections; but its radical defects, in so far as gas interests are concerned, are, firstly, its permissive character—it is only legally operative in any place or district after the magistrates or other duly constituted authority of such place or district have resolved to adopt it. Secondly, its rules for testing meters are so inadequate to the requirements of meter-testing that they render the legal verification of many meters simply impossible by the instruments at the command of meter inspectors; and further, the rules provide for no examination of indexes.

The effect of the permissive character of the Act is, that after an existence of 10 years it is now only legally operative in one county and 52 cities and boroughs in England; so that two important purposes which the Act was intended originally to serve—namely, the compelling of all meters to be stamped, and the establishment of inspectors locally, in order that they might be readily appealed to in case of dispute—are, to a great extent, frustrated. That verified and stamped meters are almost universally employed throughout the kingdom renders the present state of the law scarcely the less objectionable; for, although the stamp on a meter may be referred to, and a certificate of registration produced in any district, yet such evidence will not carry conviction into the minds of consumers so well as would the testimony of a local inspector, who might possibly be a man well known to and respected by those who appealed to him.

Moreover, a system which necessitates many meters to be sent miles away to be tested, and to an inspector unknown to all parties concerned, is little likely to satisfy consumers. The opportunity given to the company, in many instances to have the meter altered and adjusted before it reaches the inspector, must excite the suspicion of consumers; and, although the author is quite aware of the groundlessness for such suspicion, still he knows that it is at times excited, and that the results of official testings have been, in consequence, discredited. Expense, too, is another element which is of some importance when a meter is sent far away. The verification of meter indexes is a matter of vital importance. Under the present system, a meter may be fitted with an index of erroneous construction, or one intended for a meter of another size, and such meter may be verified and stamped without any discovery, by the inspector, of the false registration. Meter-makers, as a matter concerning their reputation, take

every imaginable care to avoid errors in respect to indexes; but so they also do, and have done in times past, in respect to the actual measuring capacity of their meters; and, if it be deemed needful to verify meters in respect to *capacity*, in which the *smallest* amount of error is possible, surely it is of much greater importance to verify the *registering* apparatus, in which the *largest* amount of error may be made.

This matter—that is, the making of mistakes—concerns gas companies more than meter-makers. Many gas-fitters undertake the repair of meters, and do them somehow for consumers, and in their hands indexes may be altered erroneously, or wrongly changed, and the discomfort resulting, sooner or later, is certain to fall on the gas company, and the discredit possibly on the maker of the meter. If the index were verified, this source of error would be avoided. The testing of large meters, in a legal manner, is rendered impossible by the rigidity of the rules which have to be oberved, and the positive insufficiency of the apparatus which an inspector has to employ, and is able to employ, in many instances. It is enacted by the Act that every meter shall be tested under a pressure of 5-10ths of an inch of water, and when passing the quantity of gas or air per hour which shall be marked on the meter as its measuring capacity per hour. The instruments which the authorities put into the possession of the inspectors, in order to carry the testing rules into effect, are gasholders of $1\frac{1}{10}$, $5\frac{1}{2}$, and 11 cubic feet capacity. Of these sizes the 11 cubic feet gasholder is mostly employed. Now, at the outset, there are practical difficulties in the way of putting connexions of a larger size than 2 inch to an 11 cubic feet gasholder, as there are also in the way of *using* holders with larger connexions. Hence the maximum rate of delivery of air or gas from a holder is soon reached, and it is found that, with one 11 cubic feet holder, it is impossible to deliver gas under 5-10ths pressure fast enough to work any meter above about 80 or 100 light size at full speed; but, even assuming that a 100-light could be so tested, a difficulty arises. A 100-light wet meter should deliver 5 cubic feet of gas per revolution; two revolutions nearly exhaust an 11 cubic feet holder; and much more than such quantity must be passed through fairly to test the meter. Thus with one holder the test must be intermittent, and this method of testing is very likely to lead to error. It is true two holders could be used, and consecutively filled and discharged. This would meet the requirements perhaps of a 100 light, and at the same time give the inspector just as much work to do as one man could accomplish. Much larger meters than the 100-light size are used in most towns, and in order to test such meters according to legal rules, it would be needful for the inspector to be provided, at enormous expense, with many holders and their accompaniments, to have a staff of experienced assistants, and a large establishment to keep the apparatus in. No corporate body would feel or have felt justified in incurring such an expense as would enable an inspector to comply with the legal requirements of extreme or even of mean cases.

But the difficulties do not terminate at the point indicated, for clause 20 of the Act empowers an inspector to enter a consumers premises and therein test the meter, or to have it removed for testing. Many consumers meters are very large, and are fixed in such situations that their removal would be attended with difficulty, expense, and even destruction of property. Such meters must be verified *in situ*, but unless the inspector bring to the place a number of gasholders and fittings at a great cost, he cannot test the meters in a legal manner. Hence it is that inspectors have not hesitated to violate the rules, and to make the best tests in their power, by the use of one gasholder, and at whatever rate of working possible, while the test for leakage under 3 inches pressure has been in most cases entirely neglected. There are hundreds of meters in use which have in this way been illegally verified and stamped. It is now fully time that earnest efforts were made to alter a state of things which will some day cause serious discomfort to many gas companies. It is a field which may yield a prolific crop of distrust in respect to gas companies, meter inspectors, and meter-makers. It may be said, if the rules laid down by Parliament for the consumer's protection be violated in one direction, that in no other direction is the Act to be relied upon, and as a consequence disputed accounts will multiply in number. Consumers may not be inclined to rest satisfied by a statement of the fact that the registration of a meter, especially of a wet meter, may be just as accurately determined at a low rate of working as at full speed.

What is needed is a complete alteration in the system of verifying large meters; the rate of working must be left to the discretion of the inspector, the condition as to pressure abolished, and the testing instrument be a meter instead of a gasholder. The operation will then become easy and accurate, and of course legal, instead of being, as it now is, troublesome, of doubtful accuracy, and illegal. The writer has for years been an advocate for the use of test-meters by inspectors, and, in conjunction with others, sought to render it a legal instrument before the Sales of Gas Act came into operation. He has at last the satisfaction of seeing it included among the standards of the Board of Trade, and rendered a legal secondary standard of cubic measurement by an Order in Council, dated the 24th of March last. The Government authorities are now prepared to verify test-meters, and it only now remains for those who are interested in meter-testing to seek for the removal of all impediments to its use.

The Royal Commission on Weights and Measures made what the author cannot but think to be a great mistake, by including the dry meter among the secondary standards. Certain it is that no inspector who possesses any practical knowledge of meters would think of using a dry meter for testing purposes, even if such meters were likely to stand the process of verification at the Standards Department. The most material reasons against the dry meter, and in favour of the wet, for *testing purposes*, are as follows, and these reasons were submitted by the author to the warden of the standards in July last:—

Dry Meter—Reasons against.—The measuring-chambers are composed partly of flexible material; and measurement is, moreover, dependent on the preservation under all conditions of use, of the absolute soundness of the slide-valves, by which gas or air enters into, and is discharged from the measuring-chambers. The dry meter is subject to disturbing influences, which alter its measuring capacity, and the existence of such disturbing influences could not be known at the time of using the meter, or even before or afterwards. The meter might, under conditions apparently identical, or at all events under conditions in which an inspector could use it, vary to the extent of 2 or 3 per cent., and the inspector know nothing of such variation. No means can be devised which will enable a dry meter to give internal or external evidence of its measuring condition, and therefore it would become necessary, if the dry meter were used for testing purposes, to reverify it at frequent intervals.

Wet Meter—Reasons for.—The measuring-wheel of a wet meter is composed of inflexible material, and is practically incapable of any variation in capacity, except that produced by the elevation or depression of the water level. The measurement is, moreover, independent of any valves whatever. It is free from any influences capable of disturbing its measurement when used under conditions, which the inspector can command and control. It affords internal evidence of its own measuring condition, for the wheel being inflexible and unchangeable as to dimensions, and the depth of its immersion being defined by lines upon water-level gauges, it follows that it is only necessary to charge the meter, on every occasion of using, to the lines on the gauges, to secure optical evidence of the meter's measuring condition; hence retesting at frequent intervals is unnecessary.

The standard test-meters are respectively 20-light and 100-light size. The 20-light model before the meeting shows the construction adopted. The wheels are made of very stout incorrodible metal, and the cases are also lined with the same metal one-eighth of an inch thick; so that the meters are as durable in character as the other Government standards. The standards of cubic measurement now comprise three distinct kinds of instruments—viz., the *cubic foot bottle*, the *test gasholder*, the *test meter*. These instruments differ widely from each other in character and mode of measurement, and the writer believes it will be of interest to consider briefly the conditions under which each may used in order to secure accurate measurement; the dry meter may, however, be passed over, because the reasons already given show that it is not fitted for testing purposes. At all events, the writer has failed to discover any means by which it can be made to satisfy the requirements of meter-testing or of very precise measurement. The cubic foot bottle is merely an outcome of the late Mr. King's "Transferrer." The "Transferrer," in truth, consisted of a cubic foot bottle mounted above an air-chamber, and communicating therewith by means of a syphon-pipe provided with a cock, so that connexion between the bottle and air-vessel could be established or cut off at will. The hypothesis

on which this instrument was constructed is, that if the upper vessel or bottle be charged with water, and the water then be discharged into the air-vessel below, a quantity of air exactly equal to the volume of water admitted would be expelled from the outlet of the air-vessel. The suggestion of the bottle form for a cubic foot measure was not lost upon the Astronomer Royal and Professor Miller, and this form was adopted for the standard, with the idea apparently of using it in some such way as Mr. King had devised. Unfortunately, Mr. King's hypothesis was not borne out by the experience of any one who worked with the transferrer. It was found that the volumes of air discharged from the chamber sensibly differed, and that it was impossible to control or even to fully realize the circumstances which induced the variations. In addition to which objection, the labour was considerable, for 62,321 lbs. of water had to be lifted for the purpose of charging the bottle for each cubic foot of air measured, and the operation was altogether slow and tedious. The writer was greatly distressed in his efforts to use the transferrer for the graduation of test gasholders in the year 1861, and after a week's unprofitable labour cast the transferrer aside, and applied the bottle as a direct measurer, in the manner shown in drawing No. 1, being at the time quite unaware that Mr. George Glover had previously devised the direct transferrer, shown in drawing No. 2. The writer ventures to think his method the best. The measurement is nearly automatic, requiring little more than a very moderate increase and reduction in the counterpoise by means of convenient loose weights, in order to discharge and recharge the bottle. On this method the operation of measuring a test gasholder is reduced to the minimum in labour, is exceedingly expeditious, and if the operator be experienced, the results are almost unfailingly accurate.

There is yet another method of using the cubic foot bottle—namely, that employed by the gas examiners of London for testing experimental meters. A bottle illustrative of this method was exhibited at the last meeting by Mr. Sugg, and a drawing of the apparatus appears in the published proceedings. The bottle terminates at each end with a glass tube, the lower marked to indicate the zero, and the upper marked to indicate the terminal point. The bottle is provided at top and bottom with suitable stop and vent cocks, and a pipe connects the lower part of the bottle to a water-cistern, while the upper part of the bottle is put into communication by means of another pipe with the instrument to be verified. Water is admitted at a regular rate through the lower cock, after adjustment to the zero line, so as to give a uniform flow of air from the bottle, and at any desired or possible pressure. The arrangement is, undoubtedly, a very excellent one, and serves its purpose well, but it is attended with various disadvantages—first, the water must be supplied from a cistern above the bottle, and this cistern must either be of somewhat large area or be placed several feet above the bottle, as otherwise the reduction of head which takes place will affect the rate of discharge to such an extent as to render necessary a constant attention and adjustment of cocks; second, a cubic foot of water is needed for every cubic foot of air measured; hence, either much water must be wasted, or the labour of lifting or the more objectionable process of pumping up from a lower cistern resorted to.

These objectionable and troublesome processes are all avoided in the writer's method of using the bottle as a meter measurer. It is simply to interpose a well-made wet governor between the air outlet of this transferrer (drawing No. 1.) and the meter. No error can or does arise from the intervention of the governor. The latter is weighted to the needful extent, the bottle, governor, and meter are first connected together by pipes and their aëriform contents brought into equilibrium with the atmosphere. The instant the discharge of air from the bottle commences, the governor comes into action, and when the bottle is fully emptied of air, the gasholder of the governor descends and delivers the air which it has received, through the meter, and all once more comes into equilibrium with the atmosphere. This system has been severely tested by the writer, and appears both on the grounds of reasoning and of demonstration to be free from objections, while it certainly possesses strong claims on account of its simplicity, the small amount of trouble it demands, and the continued use of the same volume of water, which last may therefore be readily brought to and maintained at a due temperature. It is to be understood, however, that such direct measurement from the bottle is by no means a necessity in the case of a meter, and can only be readily applied to small meters. The method, moreover, does

not give absolute accuracy, for the cubic foot of the bottle is a cubic foot under atmospheric pressure only; but the error is very small, inasmuch as under a mean barometric pressure, and with a meter or other measure opposing a resistance of so much as half an inch water pressure, the reduction in volume would be no more than 1·768th part, or just over $\frac{1}{8}$ per cent.

The test gasholder is so well known that it is needless to describe it (there is a model before you), while it would simply be a waste of time to describe that, to you, familiar instrument, a wet meter. Nevertheless, the conditions which affect these instruments, and under which they can be made to measure accurately, may be fairly treated upon.

A gasholder of the usual construction is capable of measuring volumes of gas, while in a state of compression, equal to, exceeding, or in deficit of the atmosphere, these different states of compression being obtainable by the employment of such a number of moveable weights, acting in opposition to the weight of the holder, as will suffice to equipoise it exactly, or to dispose it to rise or to fall with any desired degree of force. As a theoretical proposition, it may be said that a gasholder is an instrument capable of measuring gas independently of pressure or friction, and that friction, in instruments capable of holding and measuring gas, tends generally to the compression of gaseous fluids.

A gas-meter differs widely from a gasholder in its conditions of measurement. In a meter, friction, or resistance, is an essential element. A meter requires power to drive it; this power must be derived from the gas to be measured, so that the gas must be delivered into and pass through the measuring-chambers under some sensible pressure—*i.e.*, in a state of compression greater than that of the atmosphere, and can only be measured while in this greater state of compression. The practical effect of this has been shown to be small; but another important difference in measurement arises from the displacement of water from the measuring-chambers, which displacement increases as the working speed is increased, and renders the meter *slow;* that is, causes it to register *less* than the true volume passed through it. This fact leads to an important proposition—viz., What are the conditions under which a *test* or *standard wet meter* must be employed, in order to secure the closest approximation to true measurement?

If the capacity of the meter has been determined at its normal rate of working, and the water-level defined by marking the gauges when the meter is not working, and when only the atmospheric pressure is acting within it, then the meter must always be charged with water to the indicated level when open to the atmosphere; and it must always be used at its normal rate of working, or, if worked at other rates, the per centage of error due to such rates must be experimentally determined and allowed for. Practically, the error due to varying rates is not likely to exceed about *one per cent.*

If the capacity of the meter be determined at its normal or at any rate of working, and the water-line be defined while the meter is working at the same speed, and the pressure of the inlet gas be acting in the gauges, then the meter can be made to measure correctly at any speed, by the simple process of adjusting the water-line while the meter is working at the rate desired. More water will necessarily be needed in a meter when worked at a high speed, in order to provide for the difference in the levels within and without the wheel.

All large meters, to which gauges are affixed to indicate the water-level, should have the water-line defined while the meter is in motion. The advantages are, that an inspector could test a wet meter at any convenient or possible rate of speed, marking the "working line" while it was in action, disconnect his testing apparatus, set the tested meter in full action, and then add the needful quantity of water to make it measure correctly. Further, an inspection of the water-line when the meter was in full action would at once show whether it was properly charged. The increased accuracy of registration on this system would in many instances possibly amount to 2 per cent. On the usual system the gas must be shut off from the meter before the water-level can be adjusted, causing at times much trouble and inconvenience.

In conclusion, the writer begs to submit the following as the most important points for the consideration of the members of this association:—

1. The advisability of reverifying meters at moderate intervals, with a view to secure the more accurate registration of gas to consumers.

2. The desirability of extending the compulsory application of the Sales of

Gas Act to the whole kingdom, so that disputes, &c., may be settled by appeals to local inspectors.

3. The propriety of urging on the Government the necessity of amending the Act, so that its provisions may include the verification of indexes, the use of the test-meter, and free scope for the exercise of the judgment of the inspector in the testing operations.

If it be thought desirable to seek for amendments in the Act, the representations of those interested will now have greater force than heretofore, in consequence of the recommendations made last year by the Standards Commission, which embrace some of the points herein mentioned, as well as others with which gas companies would do well to make themselves acquainted.

Mr. KEARNEY (Clonmel), speaking of the difficulty of ascertaining the true water-line in consumers meters, said he thought it would be well if an external gauge or indicator were employed.

Mr. WARNER said the idea of having an external gauge or indicator had been theoretically but not practically carried out. Some years ago there were several attempts of the kind, and Messrs. Hulett and Paddon had a patent for its use. Another modification of it was by Mr. Smith, who employed a pointer passing through a stuffing-box on the front of the index. There were also several attempts made to put a water-gauge upon the sides of the square front, but the gauge-glasses got broken, and it appeared that at the present time there were no practical means of indicating the water levels. One point touched upon in the paper, which he as a practical man thought worthy the attention of the association, was the importance of the periodical testing of the meters, especially of dry meters. He had tested both kinds at intervals of about five years—*i. e.*, the company's meters; the customers meters he had been rather afraid of touching, because of the expense, but he thought it would have to follow very close upon the other. It certainly ought to be done once in about every five years.

Mr. D. LANE said if it were considered very desirable by gas managers or gas-meter makers to have an external means of determining the water level in meters, the method employed for steam-boilers might be used, and that would get rid of the difficulty about stuffing-boxes, and the danger of gauge-glasses breaking.

Mr. SPICE expressed his extreme gratification at listening to the able paper just read. He wished simply to make a remark on one point, and that was with regard to the objection to dry meters, or rather with reference to the difficulty of keeping them in perfect order. It had fallen to his lot to observe that meters, when applied to public lamps on the average meter system, had on close investigation produced results which were of the most startling character. The meter on one public lamp had recorded as the result of the year's working a consumption of 18,000 cubic feet, while another, which had given apparently the same light, recorded a consumption of only 6000 or 7000 feet, and this had gone into the average. Such varying results, under similar circumstances, created so much discontent in his mind that he obtained the insertion in the Chester Gas Act, four or five years ago, of a clause by which any meter which during a portion of the quarter had ceased to register gas, should be excluded from the calculation altogether in determining the average results—whether such stoppage had been for a night, a week, or a month. The result was that the next meter, which had faithfully performed its duty, governed the 12 or 24 lamps as the case might be. Now it happened that a dry meter would occasionally stand still, and yet when taken down to be tested, the valve being started, it woould be found to be perfectly correct in its measurement. This was a very serious matter for gas companies, and the difficulty was to see how this evil could be remedied. It had been said that if the meter stood still the lights would go out, but that was not always so. He had known instances in which the public lamps were alight, and the meter was standing still, with both the valves partially opened.

Mr. GREENFIELD said he thought the same observation might sometimes be made in reference to wet meters.

Mr. BROADHEAD agreed with the writer that sufficient attention was not paid to the condition of the indexes. He had known cases in which they had worked backwards.

Mr. MILES thought the testing of meters had been too much neglected. He asked for an opinion as to how often 3-light meters should be watered.

Mr. CHURCH felt bound to record his thanks personally to Mr. Hartley for his very valuable paper, and to acknowledge that, in his opinion, Mr. Hartley had been of the greatest possible service to gas engineers. He was a man who had investigated these matters thoroughly, and those who had the pleasure of his intimate acquaintance would be most ready to express their obligations to him. On this occasion Mr. Hartley seemed to have hit the blot, and to have shown most convincingly the defects in the present system of meter-testing. It was to be hoped the matter was now in the hands of individuals who would not be content till they brought it into a more satisfactory state. He was sure all present would agree with him that the existing mode left much to be desired on the part of gas companies. But though gas-meters, whether wet or dry, had their advantages and disadvantages, there could be no doubt they were most useful instruments. Those who had had some experience in meters knew well the difficulties which water companies had had in obtaining a meter which they could trust to, and he believed that up to the present time no reliable measurer of water, under both high and low pressure, had been brought before the public attention. He could recollect the time when gas was supplied to all consumers by contract; and yet with reference to wet meters, how very few improvements had been introduced since they were invented—the reason no doubt being that the principle of them was correct. He had found that wet meters after being in use for some years became slow, arising from the water-level not having been accurately taken. To get the accurate measurement of meters, the water-level must be taken inside the drum. If there was a gauge inside and out, it would be found that, when the drum became dirty or the friction was increased, from a variety of causes, a considerable difference existed in the level between the two; the fact being that there was the water friction inside the drum, *plus* the friction of the drum itself. He thought it would be an excellent plan (though it was a question of expense, which was important) that there should be a periodical inspection of all meters by a competent authority—say, once in five years, which would be quite sufficient. There was one thing which gas managers ought studiously to regard, and that was the necessity of having meters well made. If they went in for cheap meters they must make up their minds to have inaccurate meters. They ought to encourage makers to supply the best possible meters, and to be prepared to pay a fair price for them. He could state from his own experience that indexes were sometimes imperfectly made, and no doubt occasionally they became incorrect; but when the fact was considered of the thousands of meters which were turned out annually, it was marvellous that these errors were so exceptional. It was most desirable that provision be made for testing the indexes, as well as the other parts of meters.

Mr. H. JONES said he had found that the practice was prevalent of fixing meters too small for the consumption, which he regarded as bad policy on the part of gas companies. For his own part, he never allowed anything under a 5-light meter to be fixed.

Mr. PHILLIPS said he used wet meters entirely for public lamps, and did not have the least difficulty with them. In winter they were charged with a certain portion of methylated spirits, and he had never had one stop yet.

Mr. G. ANDERSON said it was clear that they ought not to allow meters to be fixed of a smaller capacity than is due to the number of lights to be used, but the difficulty was that if, say, a 5-light meter were fixed this year, next year the consumer would probably increase his lights to eight or ten. The consequence was that the water-line inside the meter was lowered, and the company did not get full pay for the gas supplied.

Mr. R. H. JONES, with reference to the periodical inspection of consumers meters, said in one of the towns supplied by his firm it was their custom to remove all the meters to the shop every other year, and having rinsed them well out, to put them under the test. In that town they had reduced the unaccounted-for gas from 18 to below 10 per cent., and he believed it was mainly owing to this periodical inspection of the meters.

Mr. G. PARKINSON said he was prepared to admit that Mr. Hartley's paper was exceedingly good, and in the majority of his remarks he entirely agreed, especially with reference to dry meters. It was an excellent idea of Mr. Hartley's to indicate the water-line of wet meters outside the meter—to indicate it at its working capacity; but, unfortunately for the satisfactory working of that plan, the water-line so adjusted was only correct so long as the friction of the meter remained the same as that at which it was adjusted. He (Mr. Parkin-

son) had had great experience with reference to meters to public lamps. On the first introduction by the Corporation of Birmingham of dry meters for that purpose, they were the cause of great annoyance. Some time back he took down 12 meters—the greater portion of them taken down at the suggestion of the borough surveyor—and out of the 12 there were only five within the limits of the Act. One was 16 per cent. slow, another 23 per cent. slow, another 8, and another 8. The fixing of dry meters in the lamp-columns was a very severe test for them. It had been recently determined by the Corporation of Birmingham to substitute wet for dry meters in the public lamps, and a plan similar to that employed by Mr. Hawksley at Nottingham had been adopted, and so far as it had gone the plan had worked very well—viz., that of fixing the meter in a box below ground. So great was the additional confidence felt both by the corporation and the gas company in wet over dry meters, that it had been agreed to extend the average principle to one meter in 50 lamps, instead of one in every 12.

Mr. HARTLEY said he had to thank the members of the association most sincerely for the kind manner in which they had received his paper, and to assure them that the only end for which he had laboured was to secure that which was right. As a meter-maker, he was willing and desirous that the instruments which he supplied should be subject to the severest test, asking only that those who used them should give them a like proportion of the attention which was given to other machines. In respect to a water-gauge, or indicator, Mr. Lane suggested the use of a magnet and a needle. No doubt such an indicator could be applied, but it must be remembered that a meter must be of the character expressed by Mr. Warner in his paper of last year, "as delicate as the finest balance, yet rough as a grindstone." It was subject to all sorts of rough usage in carriage, fixing, and use, and it was, therefore, impossible for it to have any really delicate indicator, as the latter would certainly be liable to injury. With reference to public lamps, he was not prepared to assert whether wet or dry meters were the best, for he knew of cases in which both kinds had exhibited such variations in measurement as had been mentioned. The meters used by Mr. Hawksley had this one somewhat serious disadvantage, that they were very expensive—a disadvantage which was almost fatal to their application in many instances. It must be borne in mind that the quantity of gas recorded as consumed depended on the acting pressure at the burner and the size of the opening. It was true, in almost every case where meters were used for the public lamps, that regulators were also used; but regulators, like meters, were subject to some disarrangement, and wanted looking after. Here might part of the discrepancy in registration be sought, and another part, perhaps, in the unsonndness of the fittings. With regard to indices, he had specially referred to them because he felt that this was a vital point. Once in his experience he got into trouble through a workman putting a wrong index to a meter, and this had induced increased care; but he wanted to be protected from any chance of error. He had frequently found in old meters that the spindle-wheels had been changed by gas-fitters and others, and it generally happened that the maker was discredited. There ought to be some check. Mr. G. Parkinson remarked that the water-line of a meter would vary with an increase of friction. Necessarily so. He (Mr. Parkinson) also remarked that the system suggested in the paper, with a view to secure uniform measurement, failed to indicate the true water-line. But surely it must be evident that, while the meter-wheel was free from corrosion or deposit, if the water-level within it was kept at the same uniform height, the capacity must be uniform.

Mr. G. PARKINSON said theoretically the plan was perfectly correct, but in practice it was incorrect.

Mr. HARTLEY: The errors, if any, are very small.

Mr. G. PARKINSON said unfortunately the errors were very extensive. He went through many experiments some years ago, when Messrs. Crosley and Goldsmith's meter, which was arranged on this plan, came into use, and ascertained the fact that inasmuch as the overflow of water was subject to the inlet pressure, on increasing the friction of the meter, by adding to the number of lights (the measuring capacity being only correct so long as the friction remained the same as when the adjustment was made), the meter varied from 2 to 15 per cent. fast. Another meter made by Mr. Clegg, in which the wheel was made to float, was subject to the same errors.

Mr. HARTLEY said he also had made many experiments with Crosley and

Goldsmith's meter, and Mr. Parkinson's observations were perfectly correct in respect to it; but it must be borne in mind that that meter was altogether different from the test-meter exhibited, inasmuch as Crosley's meter had a square front and a compensating apparatus, which, while the meter was at work, continually supplied fresh portions of water to the measuring-chambers, and this, and not friction, caused the meter to vary in its registration. Meters like that exhibited, consisting of a measuring-wheel within a simple cylinder, were not subject to such variations when used in the manner described in the paper.

Mr. G. ANDERSON read the following paper:—

ON FURTHER EXPERIENCE OF TAR PAVEMENT.

In the conversation that arose on Mr. Methven's paper on "Tar Pavement," at our meeting last year, I stated that a considerable quantity of that kind of paving had been laid down at Dover; that we first laid all the paving at the new gas-works there; that we next obtained leave of the corporation to do a portion of one of the public footpaths; that in the following year the corporation took up the matter themselves, employing the men that had done the work for us.

I have now the pleasure to state that the system has been continued up to the present time, and gives universal satisfaction.

Last year we disposed of some 30,000 gallons of tar for this purpose, and, to facilitate the preparation of the material, and render it harder when laid, we have prepared the tar by extracting from it the more volatile compounds, which is much appreciated, and will, no doubt, render the paving more enduring.

As a proof of the public appreciation of this kind of paving, I may state that, on one of the roads leading out of the town, the public had been in the habit of walking on the gravel footpath of one side of the road only; the footpath on the other side of the road was laid with tar paving for a considerable distance; the public crossed over from their former favourite path, and walked on the tar paving as far as it was laid, recrossing to the other side when it finished.

The paving has been done of all breadths, from 1 or 2 feet to 15 and 20 feet wide, and to the length of several miles, as may be judged from the quantity of tar used, as before stated.

Last winter was a very severe one, and well calculated to test its durability. I have since carefully examined the paving wherever I had occasion to walk on it, and I failed to discover a single defect.

The paving is also being employed as garden-paths to houses standing in their own grounds back from the public roads. It is also being used as pavement in the basement stories of houses; and, as one proof of the hold it already has of public opinion, I may state that one of the builders in the town has made it a branch of his profession, and weekly advertises in the Dover newspapers his desire to receive orders for this kind of work.

At the Dover workhouse many of the paths have been paved in this manner, and the master has reported a great saving of shoe-leather of the paupers; and he has advised that the younger children may now have much thinner shoes than formerly, and consequently more suited to their tender years, which will give them a more active gait, and assist in depauperizing them.

We have not been content with merely the footpaths being paved in this manner; we have represented to the town surveyor that the carriage ways should also be tar-paved. We have shown him the paving at our own works, where horses and heavy traffic have been constantly passing over for the last three years, and we have succeeded so far as to try the experiment.

Early in the present year the corporation passed an order for 100 feet in length of the busiest street to be so paved.

The traffic has now been on it some two months, but before it had been a week down the shopkeepers at each end were asking to have it extended opposite their houses, it being so smooth, so clean, and so noiseless.

At the present time a length is being laid down in another street to satisfy, I suppose, the representative in the council of that ward. Of course, for the carriage ways, the *modus operandi* was somewhat different to that employed for the footpaths.

First, there were about 5 to 6 inches of tarred broken granite rolled down; next, the surface was covered with tarred granite chips, and these were rolled in, and the slightest inequality filled in; and, lastly, a coat of smaller tarred chips was rolled in to form the surface.

The town surveyor has several times reported most satisfactorily, and the surveyors from other towns in the country have been sent by their boards to inquire and report upon it.

I have now only to caution gas managers against supposing that all they have to do is to mix tar and stones together and lay them down. We have all made footpaths in this way—perhaps as long almost as there have been gas-works—and with very variable success.

I think the process is described in former transactions of this society; if not, those who wish to try it had better apply to some one who understands it, for success in this, as well as in most other things, depends upon the proper carrying out of details.

I may mention, also, that in several districts of London large quantities of this kind of paving were laid down last autumn. One road in Peckham I have observed, where the footways, about 20 feet wide, are so made. At several railway stations the platforms have been done in the same way, and I think I may say the system is likely to extend.

The sole object of this paper is to spread the information into districts where it may not be so well known, so that gas managers may, as we have done, get a sale for their tar, which very often is a drug and a nuisance, while local authorities are paying double what they need do for paving their streets.

Mr. D. LANE said that some public street pavements of this kind, executed under the superintendence of Mr. Still, at Cork, were, in his judgment, quite as good as the asphalte of Paris, and cost about one-sixth of the price. At first breeze was used with the tar, but was found not to make a sufficiently hard pavement, and ultimately clinkers from the furnace, ground under edge-runners, were employed. If laid down in dry weather, and properly levelled and sloped, nothing could be more satisfactory than this kind of pavement. It did not cost more than 2s. a square yard, whereas no flagging could be laid down in Cork for less than 5s.

Mr. BROADHEAD said in Grimsby 10,000 yards of tar pavement were laid down in 1869, at 1s. 1d. per yard; in 1870, 9000 yards at 1s.; and this year they had a contract for 4000 yards at 1s., making a total of 23,000 yards in the last three years. The corporation was so well satisfied with this pavement that by annual instalments they intended thus to pave all the footways of the town.

Mr. R. H. JONES said the Corporation of Dover were providing funds at the rate of £500 or £600 a year to lay down tar pavement.

Mr. MILES asked whether it was necessary to erect expensive apparatus for distilling the tar; because, if so, it would be a serious drawback in the case of small gas-works.

Mr. ELDRIDGE asked for information as to the *modus operandi* in constructing the pavement, and the general cost per yard.

Mr. G. ANDERSON said he went over a piece of the pavement at Cork, the other day, which had been down for five years, and found it in excellent condition, although the mode of laying it was not so good as was now adopted at Dover. As to apparatus, he might state that in his case it was used because he took the naphtha to some extent out of the tar, but it was not a necessary thing. Two years before, when the tar paving was laid down on the works, this was not done, but they did that which greatly assisted the process of construction—heated the stones. The principle was very much the same as in making clay ballast. The quantity of tar required was just as much as the stones would lick up, and therefore it depended upon the size of the stones.

The reading of papers and discussion was then brought to a close.

ALTERATION OF RULE NO. 7.

Mr. D. LANE said on the previous day a proposition was made to the effect that the past president and acting president be *ex officio* members of the committee. That the question might be brought before the meeting in order, he drew up a resolution which had been submitted to the committee and approved by them. The existing rule was as follows:—"The president, vice-presidents, treasurer, and honorary secretary shall be *ex officio* members of the committee." In place of that he proposed that the rule should read thus—"The president past president, or acting president for the preceding year, vice-presidents, treasurer, trustees, and the honorary secretary shall be *ex officio* members of the committee."

Mr. WARNER seconded the motion, which was put and carried.

PROPOSED AMENDMENT OF BALLOTING PAPER.

Mr. CHURCH said he had a proposition to make, arising out of the desire expressed by many gentlemen to have a voice in determining the place for the following meeting of the association. It was—"That the committee select the names of several towns, the same to be printed in the ballot list, and sent to every member with a request that he would vote for one of the towns mentioned in that list, or substitute the name of any other in lieu thereof, the majority of votes to determine the place of meeting."

Mr. OHREN seconded the motion.

Mr. ALLEN asked whether, if this resolution were adopted, it would be competent to name any other town in the meeting. For his own part, he thought it would be much better to leave the matter to be talked over by the members when they came together.

Mr. CHURCH said the recommendation of this alteration was that it gave the absent members a vote on the question as well as those who were present.

Mr. STOUT said the difficulty would be that if 50 members voted for a certain place, 45 for a second, and 35 for a third, the 50 members would carry their point, although 80 might be said to have voted against them.

Mr. BROADHEAD was quite opposed to the committee selecting half a dozen places, nor did he approve of giving a vote on the question to those who stayed away from the meetings, and contented themselves with reading reports of the proceedings. He was quite willing to abide by the votes of the majority in the meeting.

Mr. WARNER was inclined to think there was much good in the motion, and that it would save a great deal of time being wasted. Still there were objections to it. Something might arise at a meeting which would cause the association to desire to visit a town the following year not mentioned in the circular issued by the committee.

Mr. LANE thought the difficulty might be met by allowing absent members to vote by proxy.

Mr. G. ANDERSON said his opinion was that the association would be acting very unwisely if they increased the power of the committee in the way proposed. They would ultimately arrive at such a condition that the committee would write all the papers, and there would be no need to meet and discuss them. It would be far better, instead of adopting the resolution, to determine the next place of meeting when the members came together.

Mr. CHURCH said it was a question that he personally did not care a rap for. The idea emanated with Mr. Livesey, and, though he thought the speakers were labouring under a misapprehension respecting the motion, he would withdraw it. He was not desirous to give the committee more power than they possessed, and he did not think his motion, if carried, would have that effect.

The motion was withdrawn.

ELECTION OF OFFICERS.

The SCRUTINEERS (Messrs. Longworth and Hutchinson, jun.,) reported the result of their examination of the ballot-papers, which showed that the following gentlemen had been elected as officers, &c., for the ensuing year:—

President, Mr. Jabez Church.

Vice-Presidents, Mr. G. T. Livesey, Mr. J. Wood (Bury), and Mr. T. N. Kirkham.

Treasurer, Mr. H. Newall.

Committee, Mr. J. Somerville, Mr. A. Upward, and Mr. H. Veevers.

Auditors, Mr. S. P. Leather and Mr. A. Hersee.

Hon. Sec., Mr. W. H. Bennett.

NEXT PLACE OF MEETING.

Mr. KELSALL proposed that the next meeting be held in Manchester, which he said was the cradle of the association.

Mr. WARNER proposed Newcastle-on-Tyne, and enumerated many of the attractions offered by that town and the surrounding locality to persons engaged in gas manufacture.

Mr. ALLEN seconded the motion.

Mr. ELDRIDGE said the plan hitherto adopted of meeting alternately in the

metropolis had many recommendations, and he proposed that the next meeting be held in London.

Mr. MILES seconded the motion.

Mr. BROADHEAD said Manchester was the first honoured by receiving the association. Let it "rest and be thankful." Out of respect to the memory of their first president, the association ought to visit the town which he represented, and therefore for the seventh time he proposed that the next meeting be held in Leeds.

Mr. T. ANDERSON (Bath) seconded the motion.

Mr. SPICE said he had been commissioned to present the compliments of the chairman and directors of the Boston Gas Company to the members of the association, and to say that either next year or afterwards they would be glad to show them as much hospitality in that town as it was in their power to offer. He thought it was a refreshing sign of the times that every one wanted to have a visit from them.

Mr. FRASER thought it was a bad plan to go from the custom hitherto adopted of meeting alternately in London.

A show of hands was taken, when there appeared—

For Manchester	17
Newcastle	13
London	30
Leeds	9

The places obtaining the two lowest numbers having been struck out, a second show of hands was taken, when there appeared—

For London	30
Manchester	28

It was thereupon decided to hold the next sittings in London.

TIME OF MEETING.

Mr. PHILLIPS suggested that it would be more convenient if the meetings of the association were held after the adjournment of Parliament.

Mr. FOXALL moved, and Mr. ALLEN seconded—"That the next meeting be held on the first Tuesday in June, 1872."

Mr. COCKEY said it had been suggested that, as the directors of gas companies usually met in the first part of the month, it would be more convenient if the meetings of this association were held in the latter part.

Mr. R. H. JONES moved, and Mr. SMITH seconded—"That the next meeting be held on the second Tuesday in June, 1872."

On a show of hands, there appeared 24 for the second week, and 15 for the first week; the former was, therefore, resolved upon.

VOTES OF THANKS.

Mr. M'NIE proposed, and Mr. OHREN seconded, a vote of thanks to the scrutineers for their services, which was agreed to.

On the motion of Mr. SPICE the thanks of the meeting were presented to the gentlemen who had contributed papers and drawings on the present occasion.

Mr. T. ANDERSON (Bath) asked the association to send a deputation to attend the next meeting of the North British Association of Gas Managers.

Mr. ALLEN expressed approval of the suggestion, and thought they might also send their cordial greetings to their brethren in Scotland, through Mr. Whimster, the president of the North British Association, who was now present.

Mr. CHURCH said he thought the invitation should come from the Scottish Association, and that this meeting should not appoint a deputation unasked. They might very well send their compliments, and invite a deputation to attend the next meeting of this association in London.

Mr. FRASER felt it would be desirable that there should exist a bond of friendship between the two societies. The Scottish Association, though smaller in point of numbers, was older in years, and it had been very successful. The members took a great interest in the proceedings of this association, and he was sure if a deputation were appointed to attend their meeting, in July next, it would be most kindly received.

Mr. COX moved—"That the warmest thanks of this meeting be presented to

the committee for the able manner in which they have conducted the business of the association in the past year."

Mr. STORER (Stafford) seconded the motion. He said the members of the association were not always unanimous, but he felt sure on this motion the committee would carry all with them, and that the vote would be hearty and unanimous.

The resolution was most cordially adopted.

Mr. GARNETT acknowledged the vote. He said he was quite sure they would all admit that there were times and seasons when duty no less than inclination—on this occasion they ran in parallel lines—required that they should return thanks for the kind support and help they received in the discharge of the obligations they had to fulfil. He need hardly say, because, by the vote just passed the members had expressed their appreciation of the fact, that whenever the committee met they were most anxious to promote, in every possible way, the welfare of the association. There existed amongst them a thorough brotherly feeling, and a determination, by united action, to increase its efficiency and enlarge its influence; and that which gave them confidence and satisfaction in their labours was the kindly reception which they always met at the hands of the members. The bringing together a large number of gentlemen, engaged in one of the most important manufactures of the day, helped to break down many little asperities and to foster friendships for which otherwise there would be no opportunity, and showed that, whether great or small, each had something to contribute to the common stock of knowledge and experience from which all might personally derive profit and delight, to carry back with them for the benefit of those whom, as gas managers, they represented. The committee were happy to be engaged in the necessary arrangements for this purpose, and in their name he desired to thank the members for the cordial way in which their services had been recognized.

On the motion of Mr. R. H. JONES, a vote of thanks was presented to Mr. Newall for his services as treasurer.

The PRESIDENT said he had a proposition to make which required no comment, but would receive at once the cordial assent of the meeting. It was—"That the sincere thanks of the association be presented to the President and Council of the Royal Dublin Society for granting the use of their rooms, and to Dr. Steele, Dr. Reynolds, and other officials, for the courtesy shown by them in the arrangements for the reception of the members."

Mr. CHURCH said as an Englishman he felt great pleasure in seconding the motion, and would only add that he was sure every member of the association would go away with a most excellent impression of Dublin. They owed a vote of thanks to their Irish friends generally, for they had been received most hospitably; and, in carrying the present motion, they would do it not formally, and as a mere compliment, but with the utmost sincerity and satisfaction.

The motion was put, and carried unanimously.

Mr. CHURCH said there was another motion which must not be lost sight of, and that was a hearty vote of thanks to their esteemed friend, the president, on this occasion. Placed in the chair under very disadvantageous circumstances, Mr. White had performed the presidential duties most admirably, and he was well entitled to, as he was certain to receive, the grateful acknowledgments of the members for his services.

The motion was at once and unanimously adopted.

The PRESIDENT: Gentlemen, I cannot but be gratified with the expression of your approbation of my poor endeavours to preside over this meeting. As Mr. Church has truly said, I was called upon quite unexpectedly to occupy this place, and I felt most reluctant to undertake the duty, not being accustomed to the conduct of public meetings of any sort. However, having accepted the office of vice-president, which I did certainly supposing the contingency which has arisen was very remote, I felt that I was bound to accede to the desire of the committee, and take the chair here in the absence of your elected president. I therefore at once accepted the responsibility, and though, in the discharge of my duty, I am conscious of very great defects, I can assure you I have done my best, and I am much obliged to you for the kind manner in which you have received those services.

On the motion of Mr. R. H. JONES, it was resolved—"That the thanks of the association be presented to the directors of the Alliance Gas Company, and to Mr. Somerville, their engineer, for the opportunity afforded the members to

visit the works of that company, and for the courtesy and hospitality with which they were received."

Mr. OHREN then moved a vote of thanks to Mr. W. H. Bennett, the honorary secretary of the association, and in doing so said he felt it was needless to say one word respecting the admirable manner in which the duties of his office had been discharged. He would only observe that the association were under great obligations to Mr. Bennett for his services, and he was sure the vote would be cordially responded to.

The PRESIDENT seconded the motion. He said he knew that the honorary secretary had very arduous duties, and that he brought to the performance of those duties an amount of ability and energy which was highly beneficial to the association and satisfactory to the members generally.

The motion was cordially and unanimously adopted.

Mr. HODGSON JONES said the association had now been in existence some years, and its funds were in a flourishing state. He thought, therefore, the present was a fitting opportunity for increasing the remuneration of the honorary secretary to £50 per annum. He moved a resolution to that effect.

Mr. OHREN said he was very glad to second a motion which, if he had not been a member of the committee, he should have been the first to propose.

Mr. WARNER desired to say one word upon the motion. He was sure every one present would feel that the labour which fell to the share of Mr. Bennett, in connexion with the business of the association, was in no way compensated for by the amount which might be voted to him. Apart from other matters, the working out of the details of arrangements for the annual meeting, the correspondence with members and other persons, and the supervision of the printing of the proceedings of the association, required an amount of attention and labour which made the duties of his office very onerous. It was with great pleasure, therefore, that he (Mr. Warner) supported the motion.

The PRESIDENT said he could endorse all that Mr. Warner had stated, and felt sure that the association would not be giving Mr. Bennett a remuneration at all commensurate with his services, even when they had passed, as he was sure they would do unanimously, the motion now before the meeting.

The motion was carried unanimously.

Mr. BENNETT: Mr. President and Gentlemen, I am indeed very much obliged for the extremely kind manner in which you have been pleased to express your approbation of my efforts. I can assure you it affords me great pleasure to be in any way instrumental in promoting such gatherings as the present, and I trust long to see and rejoice in the continued prosperity of the association. With regard to the substantial token you have given of your appreciation, I can only say that the motion just passed was proposed most unexpectedly to me. I am glad to assist the association for the honour and pleasure involved in it; but, as it is your wish to add this further inducement, I bow to your opinion, and thank you sincerely for such a recognition of my services.

The proceedings were then brought to a close.

British Association of Gas Managers.

LIST OF SUBSCRIPTIONS, &c.,

Paid during the Year ending April 30, 1871.

DONATION.

Mr. Thos. Hawksley	London	£5	5	0

LIFE SUBSCRIPTION.

Mr. H. M. L. Jones	London	£10	10	0

ANNUAL SUBSCRIPTIONS.

Mr. J. L. Cocker	Merthyr Tydfil	£0	10	6
,, W. Bates	Worksop	0	10	6
,, W. J. Moon	Peterborough	1	1	0
,, T. Dand	Exeter	2	2	0
,, J. McMillan	Newry	0	10	6
,, E. Chattwood	Ramsbottom	0	10	6
,, T. Anderson	Bath	0	10	6
,, W. A. Plumbe	Sutton-in-Ashfield	0	10	6
,, W. Wood	Cambridge	0	10	6
,, T. Melling	Rainhill	1	1	0
,, Josiah Deakes	Worcester	1	1	0
,, P. J. Wates	Loughborough	0	10	6
,, C. R. Mead	Reigate	1	1	0
,, C. R. Robinson	Coventry	1	1	0
,, W. L. Robinson	Coventry	1	1	0
,, Jos. Phelps	Marlborough	0	10	6
,, Jas. Hislop	Ayr	1	1	0
,, J. Hepworth	Carlisle	0	10	6
,, B. G. Venner	Eton	0	10	6
,, J. Hodgson	Ulverstone	0	10	6
,, J. Foxall	Beverley	0	10	6
,, W. R. Cooper	Banbury	0	10	6
,, C. Hawksley	London	1	1	0
,, J. Sharp	Southampton	0	10	6
,, J. Russell	Uxbridge	0	10	6
,, J. Johnson	London	1	1	0
,, J. Rich	Devonport	0	10	6
,, R. Gardiner	Newcastle	0	10	6
	Carried forward	£21	0	0

	Brought forward		£21	0	0
Mr.	J. Aird, jun.	London	0	10	6
„	J. Reed	Newport, I. W.	0	10	6
„	D. Hunter	Greenwich	1	1	0
„	R. Morton	London	0	10	6
„	M. Ohren	Lower Sydenham	1	1	0
„	E. S. Cathels	Lower Sydenham	0	10	6
„	J. Ohren	Rio de Janeiro	0	10	6
„	T. Andrews	Swansea	1	1	0
„	W. P. Thresby	Lincoln	1	1	0
„	W. H. Chambers	Lowestoft	0	10	6
„	W. U. Tinney	Winchester	1	1	0
„	M. Broadhead	Great Grimsby	1	1	0
„	J. H. Robinson	Leamington	1	1	0
„	W. Blackburn	Hebden Bridge	0	10	6
„	Jas. Hunter	Woolwich	1	1	0
„	W. Wright	Lewes	0	10	6
„	W. Dore	Neath	0	10	6
„	J. R. Frith	Runcorn	0	10	6
„	A. F. Phillips	St. Albans	1	1	0
„	A. H. Wood	Hastings	1	1	0
„	I. Kelsall	Ashton-under-Lyne	1	1	0
„	J. Storer	Stafford	0	10	6
„	E. White	Birmingham	1	1	0
„	O. Brothers	Blackburn	0	10	6
„	G. B. Irons	Gosport	0	10	6
„	W. J. Warner	S. Shields	0	10	6
„	J. B. Ball	Yeovil	0	10	6
„	G. B. Vanheson	Rochester	0	10	6
„	R. Douglas	Newcastle	1	1	0
„	W. Fleming	Lancaster	0	10	6
„	J. Paterson	Warrington	1	1	0
„	H. Bartholomew	Glasgow	1	1	0
„	J. Macnie	Londonderry	1	1	0
„	J. H. Cox	Sunderland	1	1	0
„	D. Clarke	Sunderland	0	10	6
„	W. C. Rafarel	Barnstaple	1	1	0
„	T. W. R. White	Sherborne	0	10	6
„	R. H. Jones	Dover	1	1	0
„	W. C. Holmes	Huddersfield	1	1	0
„	T. May	Ramsgate	0	10	6
„	F. Doughty	Margate	0	10	6
„	C. Farrand	Croydon	0	10	6
„	J. Braddock	Droylsden	0	10	6
„	J. Harris	Ross	1	1	0
„	S. Studholm	Whitehaven	1	1	0
„	W. Ford	Stockton-on-Tees	1	1	0
„	J. Young	Stoke-on-Trent	0	10	6
„	J. Middleton	Wandsworth	0	10	6
„	J. H. Cornish	Bridgwater	0	10	6
„	Jas. Lowe	Bridport	0	10	6
„	A. Kitt	London	1	1	0
„	S. Hunter	Louth	0	10	6
„	W. Pritchard	St. Helen's	1	1	0
„	J. Smith	Padiham	0	10	6
„	W. Miles	Riverhall	0	10	6
„	T. Littlehales	Wormwood Scrubs	0	10	6
	Carried forward		£63	10	6

	Brought forward		£63	10	6
Mr.	W. Romans	London	1	1	0
„	H. Woodall	Longport	0	10	6
„	E. Evans	Peterborough	0	10	6
„	P. W. Hastings	Pinner	0	10	6
„	W. A. Padfield	High Wycombe	1	1	0
„	Geo. Garnett	Ryde	1	1	0
„	T. Varley	Colne	0	10	6
„	C. Wright	Saffron Waldon	0	10	6
„	C. Craven	Dewsbury	0	10	6
„	A. Potter	Newcastle	1	1	0
„	T. H. Bouttell	Sleaford	0	10	6
„	W. Stout	Boston	0	10	6
„	J. Somerville	Dublin	1	1	0
„	J. Jowett	Leeds	0	10	6
„	T. Bull	Tamworth	0	10	6
„	D. Helps	Bath	0	10	6
„	Josh. Wood	Bury	1	1	0
„	J. Niven	Clayton	0	10	6
„	J. Laycock	Keighley	0	10	6
„	F. Bower	N. Bierley	0	10	6
„	W. Smith	Hyde	0	10	6
„	R. Little	Billingborough	0	10	6
„	Geo. Helps	Bath	0	10	6
„	C. S. Robinson	Leicester	1	1	0
„	G. A. Robinson	Leicester	1	1	0
„	H. Lyon	Manchester	0	10	6
„	R. Brown	Arbroath	0	10	6
„	A. McNeil	Tiverton	1	1	0
„	E. Price	Hampton Wick	0	10	6
„	A. E. Baron	King's Lynn	0	10	6
„	C. Taylor	Derby	0	10	6
„	E. Smith	Droitwich	0	10	6
„	J. Morris	Jersey	1	1	0
„	L. Hislop	Woolwich	0	10	6
„	J. Hall	Ballymena	0	10	6
„	C. Copland	Hull	0	10	6
„	J. Read	Tunbridge Wells	0	10	6
„	Geo. Scott	Tunbridge Wells	0	10	6
„	W. Wright	Shipley	0	10	6
„	D. Burton	Ossett	0	10	6
„	T. Rafferty	Manchester	1	1	0
„	W. Barratt	Accrington	0	10	6
„	R. Gill	Bridgnorth	0	10	6
„	T. A. Drew	Crewe	0	10	6
„	G. H. Osborn	Bromley	0	10	6
„	W. North	Stourbridge	1	1	0
„	R. Fish	Hornsey	1	1	0
„	W. T. Walker	London	1	1	0
„	F. Beale	London	0	10	6
„	J. Eadington	Blyth	0	10	6
„	A. Donaldson	Edinburgh	1	1	0
„	Geo. Payne	Millwall	1	1	0
„	T. Smith	Wigan	1	1	0
„	J. Clark	London	1	1	0
„	H. Clark	London	1	1	0
„	Jas. Wadeson	Windsor	0	10	6
	Carried forward		£102	18	0

	Brought forward	£102	18	0
Mr.	P. H. Wilkinson — Harrogate	0	10	6
,,	J. W. Lawson — South Shields	0	10	6
,,	C. Tadman — Norwich	0	10	6
,,	F. Child — Sheffield	0	10	6
,,	C. W. Kitto — Tonbridge	0	10	6
,,	E. Goddard — Ipswich	1	1	0
,,	T. Giles — West Cowes	0	10	6
,,	H. Crowe — Wellington	0	10	6
,,	R. J. Fennesey — London	0	10	6
,,	E. Brickles — Santiago	0	10	6
,,	H. W. Smith — Seaham	0	10	6
,,	J. W. Pollard — London	1	1	0
,,	C. Hunt — London	0	10	6
,,	J. Waugh — Southport	0	10	6
,,	J. Rowan — Colchester	0	10	6
,,	S. Cross — Abergavenny	0	10	6
,,	W. Shimeld — Dundalk	0	10	6
,,	Geo. Smedley — Buxton	1	1	0
,,	G. C. Trewby — London	1	1	0
,,	W. Moor — Fence Houses	0	10	6
,,	J. Moir — Shotley Bridge	0	10	6
,,	Geo. A. Allan — Willington Quay	0	10	6
,,	J. Marsland — Enniskillen	0	10	6
,,	T. N. Kirkham — London	2	2	0
,,	A. Williams — London	1	1	0
,,	T Stone — Weymouth	0	10	6
,,	W. T. Carpenter — Sheerness	0	10	6
,,	R. Church — Chichester	0	10	6
,,	J. Burgess — Huddersfield	0	10	6
,,	W. Hildreth — Darlington	0	10	6
,,	I. A. Crookenden — London	0	10	6
,,	T. Livesey — London	1	1	0
,,	G. Livesey — London	1	1	0
,,	G. D. Malam — Halifax	1	1	0
,,	W. Prescott — Prescot	1	1	0
,,	M. H. Loam — Nottingham	0	10	6
,,	R. O. Paterson — Cheltenham	0	10	6
,,	W. Fraser — Inverkeithing	0	10	6
,,	Geo. Anderson — London	1	1	0
,,	W. P. Wilson — London	0	10	6
,,	R. Darney — Faversham	0	10	6
,,	J. Stevenson — Dublin	1	1	0
,,	W. C. Humphreys — Barnet	0	10	6
,,	E. L. Ridgway — Abingdon	0	10	6
,,	H. Green — Preston	0	10	6
,,	J. Dunning — Middlesborough	1	1	0
,,	A. Hersee — London	0	10	6
,,	J. Blackburn — Calcutta	1	1	0
,,	E. R. Blanchett — Calcutta	1	1	0
,,	W. R. Hammond — Deal	0	10	6
,,	P. Simpson — Rugby	0	10	6
,,	S. Cutler — Millwall	1	1	0
,,	F. Williams — London	0	10	6
,,	T. H. Methven — Bury St. Edmund's	1	1	0
,,	A. C. Fraser — Colchester	0	10	6
,,	J. Cockcroft — Littleborough	0	10	6
	Carried forward	£142	5	6

	Brought forward		£142	5	6
Mr.	J. Donaldson	Dover	1	1	0
„	E. H. Harris	Wallasey	0	10	6
„	H. Newall	Manchester	1	1	0
„	F. J. Evans	London	1	1	0
„	W. H. Willis	Great Yarmouth	0	10	6
„	J. M. Darwin	Longton	0	10	6
„	W. Duff	Morecambe	0	10	6
„	J. Church	London	0	10	6
„	J. T. B. Porter	Lincoln	0	10	6
„	W. Parlby	Aylesbury	0	10	6
„	J. A. Cowen	Blaydon	0	10	6
„	W. Foulis	Glasgow	1	1	0
„	G. J. Parkinson	Birmingham	1	1	0
„	E. Church	Huntingdon	0	10	6
„	J. Murray	Graingerville	1	1	0
„	J. Methven	Gravesend	1	1	0
„	Geo. Severs	Birstall	0	10	6
„	A. Penny	London	1	1	0
„	T. Forrest	Walker	0	10	6
„	Geo. Rait	London	1	1	0
„	J. Fingland	Todmorden	0	10	6
„	H. Cockey	Frome	1	1	0
„	J. Booth	Stalybridge	0	10	6
„	T. Trewhitt	West Hartlepool	1	1	0
„	R. Bell	Rochdale	0	10	6
„	M. Martin	Drogheda	0	10	6
„	W. Fiddes	Bristol	1	1	0
„	H. P. Stephenson	London	1	1	0
„	J. Hutchinson	Barnsley	0	10	6
„	W. W. Hutchinson	Barnsley	0	10	6
„	L H. Green	Dartford	0	10	6
„	H. Brothers	London	0	10	6
„	W. Blackledge	Bacup	0	10	6
„	D. Brandwood	Radcliffe	0	10	6
„	J. Mudie	Burton-on-Trent	0	10	6
„	J. Brown	Waltham Cross	2	2	0
„	A. Field	Widnes	0	10	6
„	J. Tindall	Walsall	0	10	6
„	D. Clark	Brymbo	0	10	6
„	J. Davies	Oswestry	0	10	6
„	H. O. Eldridge	Richmond	0	10	6
„	S. Pontifex	New Barnet	1	1	0
„	A. F. Livesay	Portsmouth	1	1	0
„	J. G. Livesay	Ventnor	0	10	6
„	Geo. Harding	Broad Green	0	10	6
„	Geo. Waller	London	0	10	6
„	A. M. Murphy	Cirencester	0	10	6
„	C. Horsley	London	0	10	6
„	W. Longworth	Dukinfield	0	10	6
„	J. Reid	Newcastle-upon-Tyne	0	10	6
„	G. Thorneloe	London	0	10	6
„	T. R. Mellor	London	0	10	6
„	R. J. Niven	Kettering	0	10	6
„	H. M'Pherson	Newcastle	1	1	0
„	W. Osmond	Dorchester	0	10	6
„	T. Bell	Selby	0	10	6
	Carried forward		£181	13	0

	Brought forward	£181	13	0
Mr. W. Syms	Rochester	1	1	0
„ G. M. Ford	Exeter	0	10	6
„ W. T. Everist	Red Hill	0	10	6
„ W. J. Larkum	Ripon	0	10	6
„ T. Hardick	Salisbury	1	1	0
„ F. Leslie	Moscow	1	1	0
„ T. Pearson	Portland	0	10	6
„ J. T. Hall	Liverpool	1	1	0
„ E. E. Jones	Menai Bridge	0	10	6
„ G. B. Irons	Gosport	0	10	6
„ J. Goodwin	Rotherham	1	1	0
„ W. Bates	Worksop	0	10	6
„ J. Eldridge	Richmond	1	1	0
„ J. McMillan	Newry	0	10	6
„ W. Brown	Manchester	1	1	0
„ C. Woodall	London	1	1	0
„ R. P. Spice	London	1	1	0
„ G. W. Stevenson	London	2	2	0
„ J. B. Coulson	London	0	10	6
„ T. Green	Heckmondwike	1	1	0
„ S. P. Leather	Burnley	1	1	0
„ H. Bowen	Cardiff	0	10	6
„ J. Annan	Wolverhampton	0	10	6
„ W. Stiven	Inverness	1	1	0
„ J. Miles	Deane	0	10	6
„ J. Arnott	Leeds	1	1	0
		£203	14	0

SALE OF REPORTS.

Mr. Josh. Wood	Bury	£0	18	9
„ J. Braddock	Droylsden	0	6	9
„ J. Paterson	Warrington	0	4	0
„ I. Kelsall	Ashton-under-Lyne	0	2	0
„ R. J. Fennesey	London	0	15	0
„ J. Rowan	Colchester	0	14	9
„ F. W. Smith	Moxley	0	14	9
„ W. Coward	London	1	9	6
„ E. White	Birmingham	0	6	0
„ W. Parlby	Aylesbury	0	4	0
„ Geo. Scott	Tunbridge Wells	0	13	3
„ W. H. Catlin	Dublin	0	4	9
„ W. Coward	London	0	9	0
„ J. Brown	Waltham Cross	0	4	6
„ C. Hunt	London	0	3	9
„ J. Hepworth	Carlisle	0	9	6
„ W. H. Catlin	Dublin	0	4	9
„ W. Sugg	London	0	4	6
„ A. F. Phillips	St. Albans	0	9	5
„ W. B. King	London	1	15	5
„ J. Wood	Bury	0	4	6
„ J. Braddock	Oldham	0	17	3
„ C. Woodall	London	0	4	6
„ D. Terrace	Leven	0	4	6
		£12	5	1

ENTRANCE FEES.

Mr. A. Donaldson	Edinburgh	£5	0	0
,, Geo. Payne	Millwall	5	0	0
,, J. W. Pollard	London	5	0	0
,, W. Fraser	Inverkeithing	5	0	0
,, F. Williams	London	5	0	0
,, Geo. Waller	Do.	5	0	0
,, Chas. Horsley	Do.	5	0	0
,, G. Thorneloe	Do.	5	0	0
		£40	0	0